Bad combination for cancer risk: Daily exposure to secondhand smoke and a low immune system

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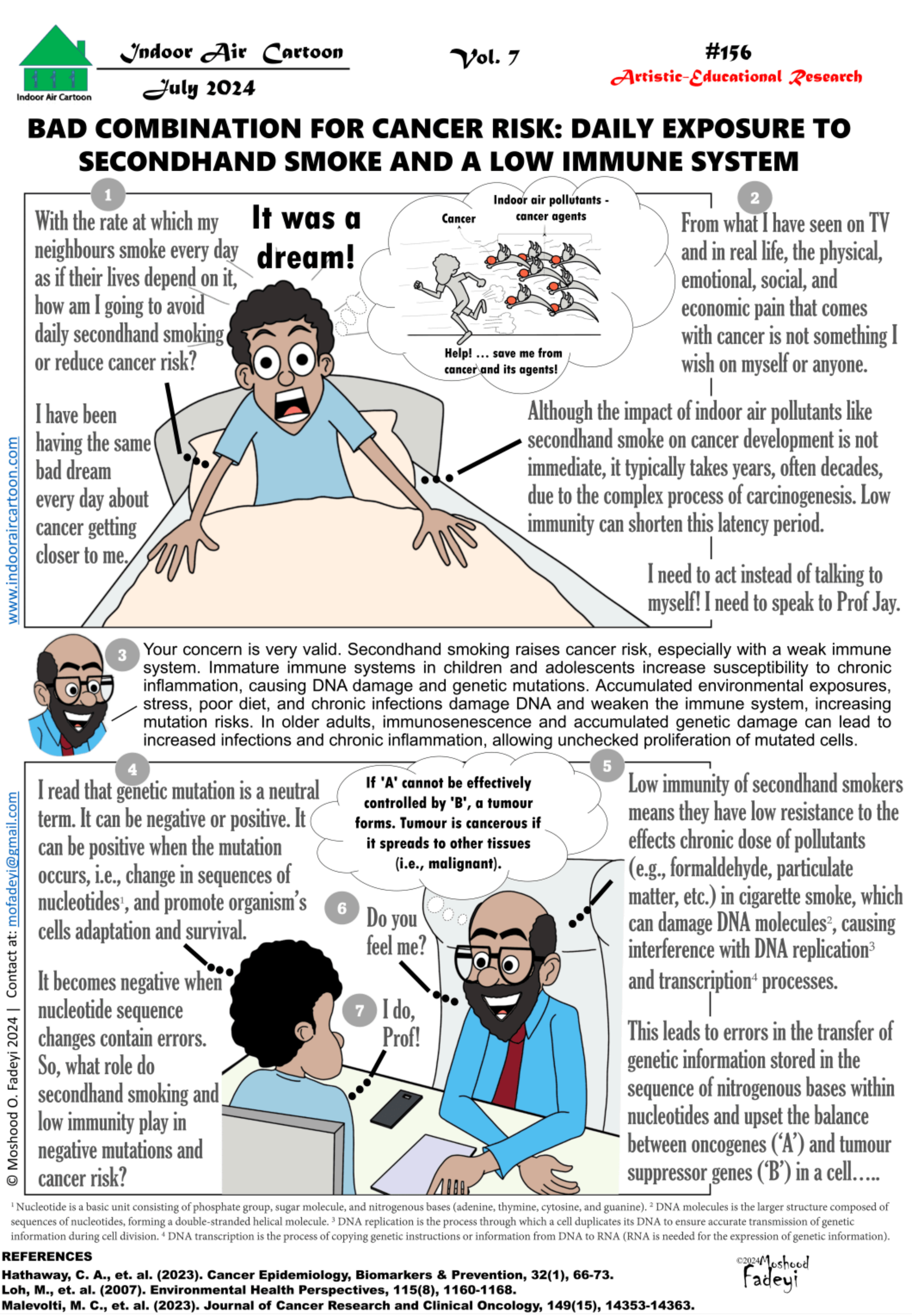

Fictional Case Story (Audio – available online) – Part 1

Fictional Case Story (Audio – available online) – Part 2

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A man lived in a high-rise building where he was constantly exposed to secondhand smoke. His concern deepened as he learnt about the heightened cancer risk associated with such exposure. Motivated by a desire to protect himself and others, the man embarked on a mission to find a solution to this pervasive problem. He faced numerous obstacles, including jealousy and scepticism from people who felt insecure about the efforts he was making, but his unwavering hope and resilience guided him. His journey was one of innovation and determination. He researched extensively, collaborated with experts, and eventually developed an effective intervention that significantly reduced secondhand smoke exposure in residential buildings and cancer risk. His solution not only safeguarded his own wellbeing but also inspired his community to do the same. Through his relentless pursuit of a healthier indoor air and awareness about it, the man demonstrated that hope and resilience could triumph over adversity. The journey of this man is the subject of this short fiction story.

1 ……………………………

Timilehin was born amidst the sounds of distant explosions and the sorrowful wails of grieving people in a makeshift hospital–a community centre converted to treat injured people and those needing urgent medical attention. Timilehin’s birth coincided with a time when Carifa, a developing country, was ravaged by civil war.

Less than an hour after Timilehin’s birth, the unthinkable happened. A bombing raid targeted the compound of the makeshift hospital, significantly damaging the building. Timilehin’s parents, who had been overjoyed moments before, were caught in the devastation. A concrete slab, dislodged by the blast, fell on them, taking their lives instantly.

Fortunately, Timilehin was not with his mother. He was in the nursery and narrowly survived the impact of the bomb. Timilehin’s nine-year-old sister, Pamilerin, who had come to the hospital with their father to see their mother and newborn brother, also survived with minor injuries. Their father used his body to protect her from the falling concrete slab.

In the aftermath of the bombing, the hospital was a scene of utter devastation. Amidst the smoke, dust, and cries for help, an injured nurse, driven by sheer determination and compassion, found Timilehin and Pamilerin. Despite her own injuries, she managed to rescue the newborn and his sister from the crumbled building. Her actions were nothing short of heroic, driven by an instinct to save the innocent lives in her care.

With great effort, she handed the siblings over to the Red Cross, who had arrived at the scene to provide emergency assistance. The Red Cross workers, trained to handle such crises, swiftly took charge, ensuring that Timilehin and Pamilerin were safe from the immediate dangers of the conflict-ridden area.

With their parents tragically killed, Timilehin and Pamilerin were now orphans in a brutal world. The Red Cross, recognising their dire situation, facilitated their evacuation from Carifa. The journey to safety was arduous, filled with peril and uncertainty. However, the Red Cross workers, driven by their mission to protect and save lives, ensured that the siblings were transported safely to a refugee camp in Nerovia, a developed country. For context, Carifa had been a colony of Nerovia. The civil war broke out three years after Carifa gained independence from Nerovia.

Arriving in Nerovia, Timilehin and Pamilerin found themselves in a sprawling tent city, a temporary home for thousands displaced by conflict. The camp, though far from a decent accommodation, offered a semblance of stability and safety. Here, amidst rows of tents and makeshift shelters, the siblings began their new life.

In the camp, the orphaned siblings met Diana, a compassionate and dedicated Red Cross worker who took them under her wing. Diana, with her years of experience in conflict zones, understood the trauma that Timilehin and Pamilerin had endured. She became their guardian, providing not only for their physical needs but also offering the emotional support they desperately required.

Diana ensured that Timilehin and Pamilerin had access to nutritious food, clean water, and medical care. Her tent became a safe haven where the siblings could feel secure and loved. Taking care of Timilehin was particularly challenging because he was a newborn. However, Diana happily and compassionately cared for him as if he were her own child. She ensured that both Timilehin's and his sister's needs were adequately met.

As Timilehin and his sister grew up, Diana established a daily routine for them to regain a sense of normalcy. Regular meals, bedtime stories, and structured activities provided a predictable pattern in their lives. Diana set up a makeshift classroom within the camp, teaching the children basic literacy and numeracy skills. This not only provided them with knowledge but also instilled a sense of purpose and hope.

Diana became a mentor to Pamilerin, teaching her how to care for her younger brother and encouraging her to pursue her dreams. This empowered Pamilerin to embrace her role as a protective and nurturing sister.

Years later, despite the hardships of camp life, Timilehin and Pamilerin began to adapt and thrive. They formed friendships with other children who had similar experiences, creating a support network that helped them cope with their trauma. Through shared stories and games, they learnt that they were not alone in their struggles.

Timilehin's curiosity and thirst for knowledge became very apparent during his teenage years. He devoured the books that were donated by aid workers and volunteers, finding solace and inspiration in their pages. His fascination with science, particularly biology and medicine, ignited a passion that would shape his future.

With Diana as their guardian, the siblings were granted asylum in Nerovia. Timilehin's and his sister's early years in the refugee camp had forged in them an unyielding spirit and a deep-seated determination to excel. By the time Timilehin started his secondary school education, Pamilerin was already studying Media and Communications at the university.

Years later, Pamilerin graduated with a first-class honours degree in Media and Communications and a distinction in her master's degree in business administration from the University of Nerovia, one of the best universities in the country and the world. She began working for the World Bank. Pamilerin's academic success further energised and motivated Timilehin to succeed in his studies too. Pamilerin served as an excellent role model for her brother.

In secondary school and during A-levels, Timilehin's dedication to his studies and his natural aptitude for science and mathematics quickly set him apart. He participated in science competitions, joined academic clubs, and consistently earned top marks. His teachers recognised his potential and encouraged him to apply for scholarships for his higher education.

Timilehin's hard work paid off. His excellent grades and impressive extracurricular activities earned him scholarships to several prestigious universities in the country. The selection process at these universities was competitive, but Timilehin's compelling personal story and his commitment to making a difference in the world helped him stand out.

Timilehin eventually decided to follow in his sister's footsteps by studying at the University of Nerovia. Another reason for choosing the University of Nerovia was its status as the number one university in scientific research and innovation in the country and top 5 in the world.

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At university, Timilehin majored in Environmental Science with a minor in Public Health. He chose this major because of an unfortunate event that had happened recently. Years after they left the refugee camp and leaving in a rented apartment together, Timilehin and Pamilerin received devastating news.

Diana, who was retired at that time, had been diagnosed with mesothelioma, a rare and aggressive form of cancer. According to medical tests, her cancer was caused by prolonged exposure to asbestos, a hazardous material known to cause cancer.

Diana confirmed to her doctor that she had possible history of exposure to asbestos in a building she used to live before joining the Red Cross. She said that occupants of the government owned low-cost residential building, where she was possibly exposed to asbestos, had to relocate when the government mandated evacuation due to possible asbestos exposure. However, she was surprised, as she had last lived in the building 32 years ago to the date of diagnosis.

Diana's doctor, Dr. Chandra, replied to her by saying that the latency period for asbestos-related cancers is typically long. It can take anywhere from 20 to 50 years after initial exposure for symptoms of mesothelioma to appear. According to Dr. Chandra, mesothelioma is a rare and aggressive form of cancer that occurs in the mesothelium, a thin layer of tissue covering most of the internal organs. Despite extensive treatments and the best efforts of her medical team, Diana's condition deteriorated rapidly, and she died.

Diana's death was a heartbreaking blow to Timilehin and Pamilerin. While Diana's illness was not related to their experiences in the refugee camp, it was a stark reminder of the dangers posed by environmental factors. Timilehin realised that many preventable health issues stemmed from environmental hazards like asbestos, polluted water, poor air quality, and inadequate waste management. He saw firsthand how these factors could devastate lives and communities, fuelling his desire to make a difference.

Thus, Timilehin decided to focus on Environmental Science to gain a deep understanding of the natural and human-made environmental factors that affect health. He was determined to learn how to identify, measure, and mitigate these risks. His coursework included classes on environmental toxicology, epidemiology, and biostatistics, where he applied his analytical skills to real-world health problems. Timilehin excelled academically, consistently earning top grades in his coursework. His professors recognised his dedication and intellectual curiosity, often inviting him to assist with their research projects.

Timilehin minored in Public Health to complement his major. This allowed him to study the health outcomes associated with environmental factors and understand the broader implications of public health policies and practices. He was particularly interested in how public health initiatives could improve living conditions and reduce the incidence of diseases in marginalised communities, similar to those in refugee camps.

Timilehin seized every opportunity to engage in research. He joined a laboratory that focused on the impact of environmental pollutants on human health, working under the mentorship of a leading expert in the field. Additionally, under the tutelage of other leading experts in the public health field, Timilehin was introduced to how technology could reduce the risk of public health problems.

As Timilehin approached the end of his undergraduate studies, he began to think about the next steps in his journey. His experiences had solidified his commitment to addressing the health impacts of environmental factors, and he knew that further education and research were essential to achieving his goals. Eventually, he graduated with a first-class honours degree and chose to apply directly for a PhD, instead of doing a master's degree first. His undergraduate CGPA (Cumulative Grade Point Average) of 4.83 out of 5 made him eligible to apply for a PhD position directly.

Timilehin applied to several top graduate programmes in environmental health and public health, seeking advanced training to equip him with the skills and knowledge needed to make a significant impact in his field.

His academic record, research experience, and again his personal story made him a strong candidate. He received offers from multiple prestigious institutions, ultimately choosing the Nerovia Institute of Technology (NIT), ranked number one for Engineering in the country and the world.

Timilehin envisioned a future where his research would lead to innovative solutions for reducing health risks associated with environmental pollutants. He was particularly interested in developing interventions that could have wider positive impact on human lives. His goal was to create a global impact, helping vulnerable populations achieve better health outcomes. He believed his work could contribute to a healthier, more equitable world, free from the health consequences of poor environmental conditions. However, he was not clear on the exact topic to work on for his research.

Timilehin spent countless hours in the library, poring over academic journals and attending seminars by leading experts in environmental science and public health. Despite his dedication, he struggled to find a topic that resonated deeply with his aspirations.

Coincidentally, Timilehin had been having a recurring dream that haunted his nights. In this dream, he found himself in a dark, confined space resembling the cramped, poorly ventilated buildings of his childhood. The air was thick with smoke and a mysterious, toxic fog carrying malignant intent. As he moved through the space, he saw shadowy figures representing various indoor air pollutants–formaldehyde, benzene, and other carcinogenic compounds–swirling dangerously around him.

In the dream, Timilehin would begin to run, desperate to escape the pollutants. The fog would thicken, and he could feel the cancerous air pollutants getting closer to him, threatening to engulf him entirely. The air pollutants include benzene, formaldehyde, and carcinogenic particulate matters which are known to be present in cigarette smoke. The fear and urgency in the dream were intense.

Timilehin knew that if he did not find a way out, he would succumb to the cancer carried by the air pollutants. Suddenly, he would see a light ahead, a clear, pure air space where he could breathe freely and be safe, and he would run as fast as he could to towards the direction of the light.

One night, the dream struck a strong chord with him. He woke up, drenched in sweat but filled with a newfound sense of purpose. The dream had shown him the urgent need to address the dangers posed by indoor air pollutants and their connection to cancer. This time, the dream felt more urgent and profound than ever before, leaving him with an unshakeable resolve. Timilehin said the following when he woke suddenly.

“With the rate at which my neighbours smoke every day as if their lives depend on it, how am I going to avoid daily secondhand smoking or reduce cancer risk? I have been having the same bad dream every day about cancer getting closer to me. From what I have seen on TV and in real life, the physical, emotional, social, and economic pain that comes with cancer is not something I wish on myself or anyone.

Although the impact of indoor air pollutants like secondhand smoke on cancer development is not immediate, it typically takes years, often decades, due to the complex process of carcinogenesis. Low immunity can shorten this latency period. I need to act instead of talking to myself! I need to speak to Prof Jay.”

Determined to explore this further, Timilehin sought guidance from Prof. Jay, a professor known for his groundbreaking work on environmental health. Timilehin shared his dream and reflections with Prof. Jay, expressing his desire to focus on how to reduce building occupants’ cancer risk due to secondhand smoke. The following is an extract from the exchanges that occurred between Timilehin and Prof. Jay thereafter.

[Prof. Jay]: “Your concern is very valid. Secondhand smoking raises cancer risk, especially with a weak immune system. Immature immune systems in children and adolescents increase susceptibility to chronic inflammation, causing DNA damage and genetic mutations. Accumulated environmental exposures, stress, poor diet, and chronic infections damage DNA and weaken the immune system, increasing mutation risks. In older adults, immunosenescence and accumulated genetic damage can lead to increased infections and chronic inflammation, allowing unchecked proliferation of mutated cells.”

[Timilehin]: “I read that genetic mutation is a neutral term. It can be negative or positive. It can be positive when the mutation occurs, i.e., change in sequences of nucleotides, and promote organism’s cells adaptation and survival. It becomes negative when nucleotide sequence changes contain errors. So, what role do secondhand smoking and low immunity play in negative mutations and cancer risk?”

[Prof. Jay]: “Low immunity of secondhand smokers means they have low resistance to the effects chronic dose of pollutants (e.g., formaldehyde, particulate matter, etc.) in cigarette smoke, which can damage DNA molecules, causing interference with DNA replication and transcription processes. This leads to errors in the transfer of genetic information stored in the sequence of nitrogenous bases within nucleotides and upset the balance between oncogenes (‘A’) and tumour suppressor genes (‘B’) in a cell. If ‘A’ cannot be effectively controlled by ‘B’, a tumour forms. Tumour is cancerous if it spreads to other tissues (i.e., malignant).”

[Prof. Jay]: “Do you feel me?”

[Timilehin]: “I do, Prof.”

After the meeting with Prof. Jay, and following additional readings, abstract reasoning, and critical and reflective thinking, Timilehin was certain of his research focus. He noted that building occupants, especially those in high-rise residential buildings who are regularly exposed to secondhand smoke, do not have real-time awareness of their exposure. Moreover, they are unaware of how this exposure and low immunity increase their cancer risk and threaten their health in general, nor of the actions needed to reduce the risk.

He thought to himself that there is a need for a solution to bridge the gap between the required awareness and the current lack of it. He decided to develop and evaluate public health awareness interventions that reduce the increased cancer risk for individuals with compromised immune systems regularly exposed to secondhand smoke.

The overarching research questions for his PhD were: (i) What are the key limitations of existing indoor air quality (IAQ) monitoring technologies in high-rise residential settings, particularly in detecting carcinogenic pollutants such as benzene, formaldehyde, and particulate matter? (ii) How can an AI-driven IAQ monitoring device be designed and developed to effectively address the identified gaps and specific needs of high-rise residents while ensuring affordability, ease of use, and integration with existing building infrastructures? (iii)

How effective and usable are the developed AI-driven IAQ monitoring prototypes in real-world high-rise residential environments in reducing secondhand smoke exposure and providing actionable, low-disruption measures for cancer risk mitigation?

These research questions informed the objectives for his PhD. The objectives were: (i) To identify and analyse the limitations of current IAQ monitoring technologies in high-rise residential settings, particularly in detecting carcinogenic pollutants such as benzene, formaldehyde, and particulate matter. (ii) To design and develop an AI-driven IAQ monitoring device that addresses the identified gaps and specific needs of high-rise residents, with a focus on affordability, ease of use, and integration with existing building infrastructures. (iii) To evaluate the effectiveness and usability of the developed prototypes in real-world high-rise residential environments, assessing their impact on reducing secondhand smoke exposure and providing actionable, low-disruption measures for cancer risk mitigation.

Timilehin’s PhD research was applied in nature. Summaries of Timilehin’s PhD research methods, and results that addressed the research questions and objectives are provided below.

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Research Methods:

Needs Assessment

A needs assessment was conducted, which is a systematic process used to identify and evaluate the factors hindering the achievement of required real-time awareness of secondhand smoke exposure, immunity levels, cancer risk, and mitigation strategies. The systematic process involved identifying the landscape of IAQ monitoring technologies and pinpointing gaps specific to high-rise residential settings. This assessment was achieved through an extensive literature review and targeted stakeholder interviews.

The literature review aimed to thoroughly understand current technologies and methodologies for detecting carcinogenic indoor air pollutants, focusing on secondhand smoke exposure in high-rise environments. It involved an in-depth examination of academic papers, industry reports, and case studies related to IAQ monitoring devices.

The review evaluated sensor technologies capable of detecting air pollutants such as benzene, formaldehyde, and particulate matter ($PM_{0.1}$, $PM_{2.5}$, and PM_{10}). Key databases such as PubMed, IEEE Xplore, and Scopus were searched using keywords like “indoor air quality sensors,” “secondhand smoke detection,” and “high-rise building air quality.”

To ensure comprehensive understanding, the review assessed the limitations of existing solutions, such as high costs, accuracy of pollutant detection in diverse environmental conditions, and ease of integrating these devices into existing building infrastructures. It identified critical gaps where current technologies failed to address the specific needs of high-rise residents or individuals with compromised immune systems, particularly in detecting intermittent and low-level carcinogen exposures in indoor air.

Complementing the literature review, stakeholder interviews were conducted to gain qualitative and quantitative insights from key groups involved in or affected by IAQ problems. These interviews aimed to capture a detailed understanding of the specific needs, challenges, and preferences of end users and relevant professionals.

High-rise residents, with no smokers in their apartments, were interviewed to explore their experiences with IAQ, concerns regarding secondhand smoke from outside their apartments, and preferences for monitoring devices. Structured interviews and focus groups were conducted with a diverse sample of residents, including families, elderly individuals, and individuals with health conditions.

Building managers were consulted to understand the challenges they faced in maintaining IAQ in high-rise buildings and their views on integrating new technologies. These consultations included site visits and detailed discussions about existing IAQ management practices, challenges in retrofitting older buildings with new technology, and logistical considerations for device maintenance.

Additionally, public health experts provided valuable opinions on the essential features of monitoring devices and effective strategies for mitigating cancer risk associated with secondhand smoke. Experts from public health institutions and universities participated in these interviews, offering insights based on epidemiological studies and public health policies.

Data collected from these structured interviews and surveys offered a comprehensive view of the needs and challenges faced by these stakeholders. The qualitative data were analysed using thematic analysis to identify common themes and concerns, while quantitative data were statistically analysed to quantify the prevalence of specific issues and preferences.

Design and Development

An AI-driven IAQ monitoring device was designed to be compact and portable. It incorporated advanced sensors capable of detecting carcinogenic pollutants such as benzene, formaldehyde, and particulate matter ($PM_{0.1}$, $PM_{2.5}$, and PM_{10}). Various sensor technologies were evaluated, including electrochemical sensors for formaldehyde, photoionisation detectors for benzene, and laser scattering sensors for particulate matter. These sensors were chosen for their high sensitivity and accuracy in detecting low concentrations of harmful pollutants.

AI algorithms were developed to analyse sensor data in real-time, identifying indoor air pollutant concentrations and patterns indicative of secondhand smoke exposure. Machine learning models, including supervised learning algorithms, were trained using datasets of indoor air pollutant concentrations and secondhand smoke exposure scenarios.

An intuitive user interface was designed, accessible via a mobile application, to provide clear, actionable insights and recommendations for reducing exposure.

To accommodate the varied IAQ within an apartment, the device was designed for placement in multiple locations. Alerts from the AI-driven monitoring device, which could be sent to a mobile application, were based on readings from each specific space. This approach ensured that residents received precise and relevant information about the IAQ in different areas of their apartment.

While alerts were space-specific, data from all devices could be aggregated to provide a comprehensive overview of the apartment's IAQ. Aggregated data helped identify overall trends and patterns, offering insights into how IAQ varied throughout the apartment over time.

Cost-effective materials and technologies were utilised to keep the devices affordable for widespread use. Low-cost plastics for housing and off-the-shelf electronic components were selected to reduce manufacturing costs without compromising durability and functionality. Advancements in technology also enabled rapid production.

Certain features were incorporated into the prototype to provide awareness that could inform actionable and low-disruption measures to reduce cancer risk for all residents, including those with compromised immune systems. A module within the mobile application was developed to provide personalised, actionable recommendations based on real-time data.

For instance, if elevated levels of carcinogens were detected, the device would suggest specific actions residents could take to reduce exposure, such as improving ventilation (if applicable), closing windows, using enhanced filtering solutions, or employing air purifiers.

To tailor recommendations to individual health conditions and immunity levels, building occupants' immunity levels were monitored using an adapted wearable biosensor that tracked physiological indicators such as heart rate variability, stress levels, and signs of chronic infection. The wearable device transmitted a generalised immune status (e.g., "high," "moderate," "low") to the mobile application that also have data from the AI-driven IAQ monitoring device.

The mobile application used the generalised status, combined with real-time IAQ data, to provide tailored risk assessments and recommendations without disclosing specific health details. This approach ensured privacy while offering personalised guidance on managing IAQ. Different levels of alert notifications (e.g., visual, audible) were provided to accommodate various user needs and preferences.

Options for integrating the AI-driven IAQ monitoring devices with existing building systems were explored. For example, if high levels of secondhand smoke were detected, the system could automatically adjust air pollutants mitigation systems or notify building management to address the issue promptly. This integration aimed to ensure minimal disruption to residents while addressing exposure risks.

Educational resources were included within the mobile application's interface as supplementary materials to help residents understand the significance of the data and the health risks associated with secondhand smoke. These resources were designed to be easily understandable and accessible, offering practical advice on reducing exposure. The device and its recommendations were made suitable for residents with both compromised and uncompromised immune systems in an apartment used for the study.

The sophistication of the AI-driven IAQ monitoring device and its mobile application facilitated regulatory compliance, linked IAQ to health outcomes, and provided objective documentation. The data generated can be used to support expert analysis, reduce disputes, and advocate for policy changes and legal action against non-compliant parties, such as cigarette smokers.

A feedback mechanism was established in the mobile application for users to report their experiences and the effectiveness of the recommended measures. This feedback was used to continuously refine the device's recommendations and functionality, ensuring they were practical and effective for all residents. Rapid prototyping techniques, such as 3D printing and circuit board assembly, were employed to develop initial models. AI-driven sensors and solutions already available on the market were used in the development of the working model.

The monitoring device, the mobile application, and the adapted wearable sensors underwent initial functionality tests to ensure they met design specifications and performance criteria. These tests were conducted in an environmental chamber that simulated real-world conditions, with controlled cigarette combustion occurring outside the chamber. AI-driven IAQ monitoring devices were placed in the chamber, and human subjects using the adapted wearable sensors and the mobile application for the monitoring device were exposed to controlled secondhand smoke at levels typically experienced in everyday life.

Testing and Iteration

The testing and iteration phase, considered part of the preliminary studies, was crucial for refining the prototypes and ensuring they met performance and usability standards. This phase included pilot testing, data analysis, and iterative refinement.

Pilot testing assessed the prototypes' performance and usability in real-world environments. Five high-rise buildings with reported secondhand smoke complaints from neighbouring units were selected. Data was collected from the 5 buildings over 2 months. These buildings varied in construction age, floor levels, and ventilation systems. AI-driven IAQ monitoring devices were installed to monitor their accuracy in detecting indoor air pollutants and providing real-time data. The user friendliness and the effectiveness of the device's mobile application in providing actionable, accurate, and relevant awareness on exposure condition and cancer risk were also examined.

Low-cost air purifiers and easy-to-make, effective filters were provided to each apartment upon the residents' request, based on their interpretation of recommendations from the monitoring device's mobile application. Measures were put in place to avoid wastage from the participating residents. With government and resident permission, smart, non-intrusive sensors were integrated with each apartment window used in the study.

The described indoor air pollution mitigation strategies provided to residents were also provided during the deployment stage described in the section below. Feedback was collected from residents and building managers through surveys and direct observation to evaluate the devices' functionality and effectiveness.

Data analysis focused on evaluating the performance of the AI-driven IAQ monitoring device and its mobile application and identifying areas for improvement. Metrics such as detection accuracy and the rate of false positives or negatives were analysed using statistical methods like regression analysis. User feedback was also reviewed to assess usability, functionality, and exposure reduction. Thematic analysis was used to identify common issues and suggestions for enhancement.

Based on this feedback and performance data, the iteration phase involved refining the prototypes. Adjustments were made to improve accuracy, usability, and affordability, including sensor calibration, interface redesigns, and material upgrades. The revised prototypes (i.e., monitoring device and mobile application) were then used in the main research study.

Prototype Deployment and Evaluation

The core of the research study centred on deploying and evaluating the refined AI-driven IAQ monitoring device and its mobile app (i.e., the prototypes) in real-world settings, specifically targeting high-rise residential buildings where secondhand smoke from neighbouring units was a persistent issue. This deployment phase aimed to rigorously assess the prototypes' performance across diverse residential conditions and provide actionable insights into their effectiveness.

The selection of 20 high-rise buildings for the prototypes' deployment was executed with meticulous attention to ensure a representative sample. Data was collected from the 20 buildings over 4 months. Buildings were chosen based on reported complaints about secondhand smoke disturbances, a criterion that directly aligned with the research's focus. The selection process was designed to capture a broad spectrum of building characteristics, such as building age, floor levels, and ventilation systems.

The sample included both newly constructed and older buildings to address variations in structural attributes. Apartments from various floor levels were selected to evaluate how height within the building impacted exposure and device performance. Given that residential buildings are typically naturally ventilated, the study included buildings with different natural ventilation setups.

In each of the selected buildings, the AI-driven IAQ monitoring device was strategically installed in various usable spaces within the apartments. The chosen locations included living rooms, bedrooms, kitchens, dining areas, toilets, and bathrooms. This strategic placement aimed to ensure comprehensive data collection on IAQ and secondhand smoke exposure across different residential environments.

The study evaluated the prototypes' ability to recommend actionable, low-disruption measures for mitigating cancer risk from secondhand smoke. Key aspects included assessing the feasibility and exposure reduction impact of recommendations.

Measures such as enhanced ventilation, improved air filtration, closing windows, and using air purifiers were evaluated for practicality and applicability, especially for residents with compromised immune systems, within the constraints of high-rise living. The effectiveness of these recommendations in reducing secondhand smoke exposure was measured to determine if the interventions effectively lowered indoor carcinogen levels, thereby reducing cancer risk for residents.

A critical part of the evaluation was determining how well the prototypes helped residents understand their exposure levels and associated cancer risks. This involved clarity of communication and usability of information.

The effectiveness of the prototypes in conveying risk levels and providing actionable insights was assessed. The prototypes needed to communicate complex health risk information in a clear and understandable manner. Ensuring that the information presented was comprehensible and actionable for all residents, regardless of their immune status, was crucial for enabling residents to take informed actions to mitigate their risk.

The study also evaluated whether the prototypes' solutions were more convenient and comfortable compared to building occupant relocation to another apartment or building. This assessment included the practicality of recommendations and adaptability to diverse needs.

The feasibility of the suggested actions and the extent of disruption for residents were examined. The recommendations offered by the prototypes were expected to be practical and easily implementable within the daily routines of residents. The recommendations were also expected to be suitable for the diverse needs of all building occupants, regardless of their health status. This adaptability was essential for ensuring the interventions were inclusive and effective for all residents.

The data collection process involved continuous monitoring of the prototypes' performance, including detection accuracy and user feedback. The precision of pollutant detection and the reliability of real-time data reporting were evaluated. This data was vital for assessing how well the prototypes met their performance criteria.

Feedback through structured surveys and interviews with residents and building managers was gathered. This feedback was crucial for assessing ease of installation and operation, and effectiveness of recommendations. Building occupants were required to provide feedback on the ease of setting up and using both the AI-driven IAQ monitoring device and its mobile application.

Residents were also required to provide feedback on how well the prototypes' recommendations helped reduce exposure to secondhand smoke and manage IAQ in general. The performance of the prototypes was also analysed using metrics such as the frequency of false positives and negatives to gauge the monitoring device's sensor reliability. This statistical analysis helped in understanding the reliability and accuracy of the device.

Statistical methods, including regression analysis and error rate calculations, were employed to analyse performance data and user feedback. This comprehensive analysis provided a clear understanding of the prototypes' capabilities and their impact on managing secondhand smoke exposure and the impact of the exposure on cancer risk effectively.

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Research Findings:

Needs Assessment

The review identified benzene and formaldehyde sensors to be generally accurate but often expensive and sensitive to calibration and environmental conditions. While $PM_{2.5}$ and PM_{10} sensors are well-established and widely available, $PM_{0.1}$ detection remains challenging due to the ultrafine nature of these particles.

Despite the availability of these technologies, significant gaps were identified. High costs and environmental sensitivity often limit the widespread adoption of advanced IAQ monitoring devices in residential settings. Furthermore, integrating these sensors into older high-rise buildings without significant retrofitting poses another challenge.

Most importantly, current technologies struggle with detecting low-level, intermittent exposures to carcinogens–a common issue with secondhand smoke infiltration in high-rise buildings. Additionally, the user-friendliness of many IAQ monitoring devices remains a barrier to non-technical users, as they often require technical expertise for installation and maintenance.

Interviews with high-rise residents, including families, elderly individuals, and those with health conditions, revealed significant concerns over secondhand smoke infiltrating their apartments from neighbouring units, corridors, and common areas.

Residents expressed a strong preference for easy-to-use, cost-effective IAQ monitoring devices that could provide real-time alerts about secondhand smoke levels. Privacy emerged as a key concern, with a preference for devices that do not store personal health data.

Building managers highlighted the difficulty of retrofitting older buildings with new IAQ technologies and pointed out the logistical challenges in maintaining and calibrating these devices regularly. They preferred solutions that could be seamlessly integrated into existing building management systems and required minimal ongoing maintenance.

Experts from public health institutions and universities emphasised the need for high-accuracy sensors capable of detecting a broad range of carcinogens at low concentrations. Furthermore, they stressed the importance of data privacy and the need for public awareness campaigns to mitigate secondhand smoke exposure. Suggested strategies included improving ventilation in high-rise buildings, implementing strict non-smoking policies, and using advanced filtration systems or air purifiers alongside IAQ monitors.

Design and Development

The design portability requirement of 5cm x 5cm x 2cm for the AI-driven IAQ monitoring device was achieved. The device’s compactness facilitated easy placement in various locations within an apartment, enhancing user convenience and versatility.

The well-controlled environmental chamber testing suggests that the AI-driven IAQ monitoring device and its mobile application met performance criteria, demonstrating accuracy in detecting and monitoring indoor air pollutants as intended. In the testing, the selected sensors accurately monitored harmful pollutants–benzene, formaldehyde, and particulate matter ($PM_{0.1}$, $PM_{2.5}$, and PM_{10}) – In cigarette smoke, suggesting the device's effectiveness in the detection of air pollutants of interest.

The chamber testing also suggested that the AI algorithms developed for the device were proficient at detecting the air pollutants concentrations and identifying patterns indicative of secondhand smoke exposure in real-time. This initial indication of success was due to training the models with extensive datasets that included various indoor air pollutants concentrations and secondhand smoke scenarios, providing precise and timely information to users.

In this well-controlled environmental chamber testing, the AI-driven monitoring device provided information on the sources of these pollutants. If multiple sources contributed to a pollutant, the device was a to provide the percentage contribution of each source and the proximity of the source to the measuring device.

The user interface design, the mobile application prototype, was completed. The application featured real-time IAQ visualisations, historical data trends, personalised health recommendations, and risk predictions. In the well-controlled environmental chamber testing, the interface of the mobile application of the AI-driven IAQ monitoring device designed to be user-friendly, effectively communicate actionable insights and meeting the planned objectives for ease of use and functionality.

The AI-driven IAQ monitoring device was made up of cost-effective and durable materials, including low-cost plastics and off-the-shelf electronic components, increasing its accessible potential to consumers as intended.

During the integration and testing phase, the device was successfully incorporated into the set-up systems of the environmental chamber. The integration process ensured compatibility with ventilation controls, filters, and air purifiers, enabling automatic IAQ management based on sensor readings and achieving seamless operation within the environmental chamber settings.

The adapted wearable biosensors available on the market effectively monitored human subjects' physiological indicators and transmitted generalised immune status to the AI-driven IAQ monitoring device without compromising user privacy. This realised the intended communication between the wearable sensors, the monitoring device, and the mobile application.

Additionally, the feedback mechanism incorporated into the mobile application allowed the users (i.e., the subjects) to report their experiences and the effectiveness of the recommended measures. This feedback was instrumental in continuously refining the recommendations and functionality of the developed AI-driven IAQ monitoring device and it mobile application.

Testing and Iteration Phase

In the preliminary field testing conducted in selected 5 residential buildings, the developed AI-driven IAQ monitoring device demonstrated generally effective ability to detect major indoor air pollutants such as benzene, formaldehyde, and particulate matter ($PM_{0.1}$, $PM_{2.5}$, and PM_{10}). However, sensor accuracy varied, particularly in detecting very low concentrations of these pollutants. Formaldehyde sensors, in particular, showed inconsistent performance linked to changes in ambient humidity.

In naturally ventilated buildings where humidity levels fluctuated with external weather conditions, the sensors frequently provided unreliable readings. For instance, in highly humid environments, the formaldehyde sensors sometimes delivered readings that were significantly higher or lower than the actual concentrations. This variability was due to the sensor's sensitivity to moisture, which interfered with its ability to accurately detect formaldehyde levels.

Particulate matter detection also encountered challenges. In buildings with high external pollution concentrations or varying air currents, the sensors had difficulty differentiating between particulate matter sources. For example, during periods of high external dust or pollen, the sensors occasionally recorded elevated particulate levels inaccurately, either overstating or understating the true concentration.

This inconsistency underscored a limitation in the device's ability to reliably monitor indoor air pollutants, particularly those related to secondhand smoke, in dynamic environmental conditions. The consequence of this is the inability of the monitoring device's mobile application to effectively calculate and provide the require awareness on cancer risk.

User feedback highlighted several areas for improvement in the IAQ monitoring device's mobile application interface. Although the interface was generally user-friendly, residents noted that the visualisations and alerts were often too basic. The colour-coded indicators and graphs designed to represent indoor air pollutant concentrations did not always provide clear or actionable information in the context of real-life situations.

For example, when high levels of formaldehyde were detected, the alerts did not convey the specific source. Perhaps, this was due to complexity involved in real-life situations. Users reported struggling to interpret these alerts as the information provided was often too generalised.

Additionally, the recommendations for mitigating exposure were perceived as insufficiently detailed. When elevated indoor air pollutant concentrations were detected, the suggested actions, such as improving ventilation, filters, or using air purifiers, lacked specificity regarding the type or intensity required.

Residents suggested that more precise recommendations tailored to the specific indoor air pollutants detected and current environmental conditions would be more useful. For instance, recommendations could include specific actions based on real-time data, such as advising on the use of particular types of air purifiers or filters based on the severity and type of detected air pollutants.

Integration with naturally ventilated buildings presented unique challenges. These buildings rely on passive ventilation, which often involves opening windows and natural airflow to regulate IAQ. With the source of secondhand smoke coming from outside in this study, the prototypes faced difficulties in providing actionable insights that could directly improve the effectiveness of using the passive ventilation strategy or using it together with air purifiers or filters in improving IAQ.

Building managers reported that while the AI-driven IAQ monitoring device and its mobile application provided valuable data, the integration of these insights into actionable changes was limited. The lack of automated systems for adjusting natural ventilation meant that recommendations from the devices had to be manually implemented by residents.

This limitation highlighted the need for more practical advice that residents could easily follow to improve IAQ, given the constraints of natural ventilation. Building managers noted that perceived discomfort and inconvenience in making intervention to the building systems to reduce exposure to secondhand smoke do deter residents from taking any action.

Prototype Deployment and Evaluation

The deployment and evaluation of the refined AI-driven IAQ monitoring devices and their accompanying mobile application in 20 high-rise residential buildings provided significant insights into their enhanced effectiveness, usability, and practicality in managing cancer risk associated with secondhand smoke exposure. This phase marked a crucial advancement from the previous testing and iteration phase, demonstrating notable improvements in performance and user acceptability.

The prototypes exhibited enhanced performance in detecting key indoor pollutants, including benzene, formaldehyde, and particulate matter ($PM_{0.1}$, $PM_{2.5}$, and PM_{10}). Compared to the earlier phase, the refined AI-driven IAQ monitoring device demonstrated greater accuracy in these measurements, thanks to improved sensor calibration and better adaptation to varied environmental conditions.

Although the challenge of perfectly detecting secondhand smoke, an external pollutant in this study, persisted, the device showed improved capabilities in distinguishing between indoor and outdoor sources of air pollution.

Enhanced ventilation and air filtration measures were more effectively integrated into the recommendations. For instance, the optimised guidance for using air purifiers or filters and adjusting ventilation strategies demonstrated a clearer impact on reducing indoor pollutant levels, even though managing secondhand smoke remained complex due to its external origin. The updated recommendations helped mitigate general indoor air pollution more effectively, highlighting a significant advancement from the initial findings.

The recommendations for improving IAQ, such as using air purifiers, filters, and enhancing ventilation, were found to be more practical and targeted in this later phase. Adjustments were made to address the specific needs of high-rise residents exposed to secondhand smoke.

For example, the revised guidance for closing windows and using air purifiers or filters was better tailored to account for varying external air quality conditions. This refinement resulted in more effective strategies for managing IAQ, although further optimisation is still needed for complete efficacy against secondhand smoke originating from outdoors.

Significant improvements were made in the clarity and usability of the IAQ monitoring device and its mobile application. The mobile application's user interface was redesigned to provide more intuitive and actionable insights. Users reported a marked improvement in the comprehensibility of alerts and recommendations, which were now more specific and actionable.

The updates included clearer explanations of measured indoor air pollutant concentrations and practical steps for managing exposure, making it easier for residents to implement the advice provided. This development addressed prior concerns about overly technical language and enhanced overall user satisfaction.

The deployment phase revealed improvements in how the recommendations were integrated into the context of naturally ventilated buildings. Although challenges remained, the updated recommendations offered more feasible solutions for high-rise living conditions.

The developed solutions facilitated more effective manual application of recommendations, such as adjusting air purifier or filter usage and implementing enhanced ventilation practices, within the constraints of passive ventilation systems. This progress indicated a better alignment of the developed solutions' functionality with real-world living conditions.

The ability of the developed prototype solutions in calculating cancer risk also improved significantly. The combination of the awareness on the cancer risk and relatively comfortable and convenient actionable and effective recommendations for reducing exposure make the residents very satisfied with the usage of the developed AI-driven IAQ monitoring device and its mobile application. The adapted wearable immunity level detector is also comfortable and convenient to use.

Conclusion from the study

In general, the deployment and evaluation of the refined AI-driven IAQ monitoring device and its mobile application in high-rise residential buildings yielded significant improvements in awareness, effectiveness, and usability, reflecting the advancements made from the initial prototype usage through to the final deployment phase. These enhancements illustrate the progress in reducing cancer risk associated with secondhand smoke and improving overall IAQ management.

Initially, before the developed solutions were introduced, awareness of cancer risk linked to secondhand smoke was notably low. Residents had limited knowledge about the health impacts of secondhand smoke and its specific connection to cancer risk. At this stage, the awareness level among residents was estimated at approximately 20%.

The absence of specialised monitoring tools meant that the residents relied primarily on their sense of smell to perceive secondhand smoke and general advice and manual methods to manage their perceived air quality and IAQ, with minimal understanding of how specific air pollutants, including those in secondhand smoke, affected their health.

During the testing and iteration phase, the introduction of early prototypes of the developed solutions began to enhance awareness by offering basic information about secondhand smoke, indoor air pollutants, and their general health risks. Although these developed prototype solutions made strides in raising awareness, the communication regarding cancer risks specifically related to secondhand smoke was still developing.

As a result, the awareness level increased to about 45%. While residents gained some insight into secondhand smoke and IAQ problems, the developed prototype solutions were still refining their ability to convey specific information about cancer risk and targeted interventions.

The most notable improvements emerged during the developed prototype solutions' deployment and evaluation phase. The refined AI-driven IAQ monitoring device, supported by an enhanced mobile application, significantly boosted residents' understanding of their exposure to secondhand smoke and IAQ problems and the associated cancer risks.

By providing clearer and more actionable insights, the developed prototype solutions raised the awareness level to approximately 75%. This increase in awareness was attributed to better communication of risk levels and more precise recommendations, which empowered residents to take informed actions to mitigate their exposure to secondhand smoke.

In terms of effectiveness in reducing exposure to secondhand smoke, the initial prototype solutions showed limited capability. With no real-time monitoring or specific interventions, the effectiveness in managing secondhand smoke was minimal, estimated at around 10%. The lack of targeted measures meant that residents had few tools to address the persistent issue of external sources of secondhand smoke.

The testing and iteration phase demonstrated some improvements in effectiveness, with the developed prototype solutions providing general advice for managing indoor air pollutants. However, challenges remained in addressing secondhand smoke specifically due to limitations in sensor accuracy and the applicability of recommendations.

During this phase, the effectiveness level was about 35%. While the developed prototype solutions contributed to managing other air pollutants, their ability to target air pollutants in secondhand smoke effectively was still constrained by the technology's limitations.

The deployment and evaluation phase marked a significant leap in effectiveness. Refined sensors and enhanced recommendations improved the ability of the solutions to offer targeted advice for managing secondhand smoke exposure.

Although challenges related to secondhand smoke from outdoor sources persisted, the prototypes facilitated a noticeable reduction in indoor air pollutant concentrations and better management of cancer risk. This phase saw the effectiveness level rise to approximately 60%, reflecting the increased capability of the developed prototype solutions to provide more practical and effective interventions.

Usability and practicality of recommendations also saw marked improvements. Initially, the usability of the developed prototype solutions was limited, with users relying on general methods and lacking specific, actionable advice. The usability level at this stage was around 25%. The testing and iteration phase brought improvements in usability, but the developed prototype solutions still struggled with providing precise recommendations for diverse living conditions. This phase saw the usability level rise to 50%.

The final deployment and evaluation phase brought considerable advancements in usability. Refined prototype solutions offered practical, specific, and actionable recommendations that were better suited to varying indoor conditions. This resulted in a substantial increase in usability, with a level of approximately 80%.

Residents found the developed prototype solutions more adaptable to their needs, and the clarity of communication and practicality of recommendations were significantly enhanced. The iterative refinements and real-world application underscored the successful evolution of the developed prototype solutions and their positive impact on public health management.

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After completing his PhD, Timilehin stood on the edge of a significant breakthrough. His AI-driven IAQ monitoring device and its accompanying mobile application had already demonstrated their potential in high-rise residential buildings, offering a solution to mitigate the lack of awareness needed to motivate actions that help in reducing cancer risk associated with secondhand smoke. As he looked back on the arduous journey, Timilehin knew that his work was far from over. Little did he know, his greatest challenges lay ahead.

Upon entering the post-doctoral phase of his career, Timilehin sought to bring his innovative solutions to the broader public. The first step was securing funding and partnerships to scale up production. He presented his findings to investors and health organisations, emphasising the significant improvements in IAQ management and cancer risk reduction his innovative solutions offered. His presentations were compelling, leading to initial support from a few forward-thinking investors. He started a company called Tech for Public Health Private Limited, further enhancing his innovation for better performance.

However, as Timilehin's invention began to gain traction, it attracted the attention of powerful entities in the established IAQ and health monitoring industry. These companies, feeling threatened by the disruptive potential of Timilehin's technology, began orchestrating a series of obstacles to undermine his progress.

One of the first challenges came in the form of a smear campaign. Anonymous articles appeared online, questioning the accuracy and reliability of Timilehin's solutions. Fabricated reports claimed his sensors were faulty and his mobile application unreliable. Timilehin responded by conducting additional independent studies. He invited renowned experts to validate his technology, and their endorsements helped to quell the unfounded criticisms.

As Timilehin's innovation gained further validation, jealousy and insecurity among competitors intensified. Several attempts were made to sabotage his credibility. In one instance, a falsified report was leaked to the media, alleging that Timilehin had manipulated data in his PhD research. This report included doctored emails and fabricated data points, making the accusations appear credible. The scandal threatened to ruin his reputation and destroy his fledgling company.

Timilehin faced the new accusations head-on. He transparently shared all his PhD research data, methodologies, and results, inviting scrutiny from the scientific community. Timilehin also hired independent investigators to trace the source of the false report. The investigation revealed that a rival company had orchestrated the smear campaign in an attempt to discredit his work and gain a competitive edge.

Despite these external challenges, Timilehin also faced internal struggles. Some members of his team, swayed by lucrative offers from competitors, left the company. This was a significant blow, but Timilehin's past experiences from childhood had taught him resilience. He reached out to colleagues from his academic and professional networks, recruiting new team members who were equally passionate about the mission of revolutionising public health through healthy indoor air.

During these turbulent times, Timilehin's wife was his anchor. She provided emotional support, reminding him of the importance of his work and the lives he was impacting. She took on additional responsibilities at home, allowing Timilehin to focus on his mission. Her unwavering belief in him and their shared vision of a healthier future kept his spirits high even during the darkest moments.

Timilehin's sister, Pamilerin, and her husband also played crucial roles. Pamilerin, with her background in public relations, helped craft clear and compelling messages to counter the negative publicity. She leveraged her network to ensure that Timilehin's voice was heard, arranging media interviews and writing op-eds that highlighted the true benefits of his innovation. Her strategic thinking and communication skills were invaluable in navigating the complex landscape of public opinion.

Pamilerin was doing what she had been doing since Timilehin was a baby: taking care of and supporting her brother in the face of adversity. She was a true sister who cared deeply for her brother. Since Timilehin was young, Pamilerin would say, "I will not allow anyone to mess with my brother while I am still alive."

Pamilerin's husband, an experienced lawyer, also chipped in. He provided legal counsel and support. He meticulously reviewed contracts, helped draft responses to legal challenges, and guided Timilehin through the regulatory maze. His expertise ensured that every step Timilehin took was legally sound, protecting him from potential pitfalls and giving him the confidence to push forward.

Timilehin's perseverance began to pay off. Public awareness of the importance of the use of his innovative solutions to reduce risks involved in exposure to poor IAQ started to grow, and demand for them increased. Yet, the challenges continued. Regulatory hurdles emerged as established companies lobbied to delay certain certifications of innovations coming out of Timilehin's company.

Timilehin, familiar with the intricate and complex processes from his experiences during his PhD research and starting his company, navigated these bureaucratic obstacles with patience and precision. He gathered comprehensive data, adhered to stringent testing protocols, and worked closely with regulatory bodies to ensure his innovative solutions met all necessary standards.

Despite these relentless challenges, Timilehin's past experiences–his rigorous academic training, his understanding of the dynamics of jealousy and sabotage, and his unwavering commitment to public health–had equipped him to persevere. His innovative solutions began to make significant inroads into markets worldwide.

The impact was revolutionary. Schools, hospitals, and residential and non-residential buildings began to adopt Timilehin's innovation, leading to a noticeable improvement in IAQ. Public health data showed a decline in respiratory issues and cancer rates in areas where the innovative solutions were widely used. Timilehin's innovation had not only fulfilled the aim that started with his PhD research but had also sparked a broader movement towards healthier indoor environments.

As Timilehin's company, initially named Tech for Public Health Private Limited, continued to gain traction and recognition, it became clear that its potential extended far beyond its original scope. The success of the AI-driven IAQ monitoring device and its mobile application opened up new avenues for growth and innovation. With a vision to expand and diversify, Timilehin set his sights on transforming the company into a global powerhouse.

The first major step in this transformation was the rebranding of the company. Recognising the need to reflect its expanded mission and global reach, Timilehin renamed the company Tech for Public Health Group of Companies. This new identity signified not only the company's broadened focus but also its ambition to be a major player on the global stage.

The growth of the company was rapid and spectacular. With the initial success of the AI-driven IAQ monitoring device and its mobile application, Timilehin capitalised on the momentum to launch subsidiaries in several countries, each specialising in different aspects of public health technology. These subsidiaries allowed Tech for Public Health Group to tailor its solutions to the specific needs and challenges of different regions, further enhancing its impact.

Timilehin's success in IAQ management spurred him to explore other areas of public health where technology could make a difference. One of the first new ventures was into water quality monitoring. Applying the same principles of AI and real-time data analysis, Tech for Public Health Group developed technologies that could detect contaminants in drinking water, providing instant alerts and recommendations for purification.

Another significant diversification was in the field of nutrition and fitness. The company created wearable devices that monitored vital signs and dietary habits, offering personalised health recommendations. These devices used AI to analyse data and suggest dietary adjustments, exercise routines, and lifestyle changes to optimise individual health. This venture quickly gained popularity, particularly among health-conscious consumers looking for tailored wellness solutions.

The company's growth was also marked by strategic acquisitions. Tech for Public Health Group acquired several smaller tech companies specialising in various health technologies, from telemedicine platforms to mental health mobile applications. These acquisitions allowed Tech for Public Health Group to integrate a wide range of services into a comprehensive public health ecosystem, making it a one-stop shop for all health-related needs.

As Tech for Public Health Group expanded its influence and diversified its offerings, Timilehin's wealth grew exponentially. His innovative vision and business acumen propelled him into the ranks of the world's richest individuals. Forbes featured him on its cover, highlighting his journey from a born into a world of crisis to a global business magnate. Despite his immense wealth, Timilehin remained committed to his core values of self-respect, truth, and clear conscience, ensuring that his business practices always reflected these principles.

The impact of Tech for Public Health Group was profound. In cities worldwide, residents enjoyed cleaner air and better health, thanks to the company's innovative IAQ solutions. In rural areas, access to clean air and water and health monitoring devices transformed lives, reducing disease and improving overall wellbeing. The company's nutrition and fitness technologies helped millions lead healthier lives, and its telemedicine services brought quality healthcare to remote and underserved populations.

One of Timilehin's notable global contributions was making public health solutions, including those related to IAQ, accessible and affordable to people in developing countries, including his birthplace, Carifa.

Timilehin's personal journey was equally inspiring. His wife, who had been his steadfast supporter, now managed a foundation dedicated to providing scholarships for students in STEM fields, ensuring that the next generation of innovators had the resources they needed to succeed. Pamilerin, his sister, continued to play a crucial role in the company, heading the public relations and communications division, while her husband served as the company's chief legal officer, navigating the complex legal landscape of a multinational corporation.

The success of Timilehin and his sister, Pamilerin, was deeply rooted in their past. Their parents, who had tragically died in a civil war just a day after Timilehin was born, left behind a legacy of resilience and hope. This profound loss became a powerful motivator for Timilehin and Pamilerin, inspiring them to overcome adversity and strive for excellence in all they did.

Central to their story was Diana, the Red Cross officer who had become their guardian after they relocated to Nerovia. Diana's unwavering dedication and compassion provided a nurturing environment for Timilehin and Pamilerin, allowing them to grow up with a sense of purpose and resilience. Her influence was profound, shaping their values and fuelling their determination to succeed. Diana's guidance instilled in them the belief that even in the face of tremendous hardship, they could achieve greatness and make a meaningful difference in the world.

As the Tech for Public Health Group expanded globally, transforming IAQ management and improving public health through advanced AI-driven technologies, Timilehin's achievements became a testament to the power of perseverance and integrity. His journey from a young researcher facing severe challenges to a leading figure in global public health was not just a personal triumph but a legacy of the values instilled in him by his experience. His children and Pamilerin's children, growing up in an environment enriched by the legacy of their parents, were inspired to continue the tradition of making a difference.

Timilehin's story and that of his sister, Pamilerin, became a beacon of hope and a reminder that the most profound successes are often born from the most significant challenges. Timilehin's legacy, marked by innovation, resilience, and the unwavering support of loved ones, continued to inspire future generations, ensuring that the memory of their parents and Diana lived on through their contributions to a better and healthier world. **The End!**