UNICAMILLUS

UniCamillus Global Health Journal

no. 5 | issue 1 | pages 72 | December 2023

tab edizioni

Editor-in-Chief: Gian Stefano Spoto
Scientific Editors: Alessandro Boccanelli and Laura Elena Pacifici Noja
Registration no.: 103/2021, Ordinary Court of Rome
2 issues per year
ISSN print: 2785-3713
ISBN print: 978-88-9295-845-6
ISSN open access: 2785-4329
ISBN open access: 978-88-9295-846-3
Contributors: Luca Bello, Francesco Cattaneo, Giancarlo Ceccarelli, Massimo Ciccozzi, Monica D'Amato, Valentina De Biasio, Oritseweyinmi Erikowa-Orighoye, Anita Fortunato, Francesco Marchetti, Massimo Papa, Andrea Pettini, Gian Stefano Spoto, Maria Angela Wangui Maina.
No. 5 | issue 1 | December 2023
First edition December 2023

tab edizioni

viale Manzoni 24/c
00185 Roma
www.tabedizioni.it

UniCamillus Global Health Journal

UGHJ

edited by Alessandro Boccanelli
and Laura Elena Pacifici Noja

no. 5 | issue 1 | December 2023

Table of Contents

Preventing the future

by Gian Stefano Spoto*

Health and finance: these two themes already sound odd if combined together. Health is indeed a sacred right, while finance evokes speculation, so far from Aesculapius.

The relationship between public and private is strongly affected by these distances, often unbridgeable, in every field. We can take as an example the luxurious African capitals: here, five-star hotels are wonderful oases in cities that lack sewers, and where private owners who run the hotels do not contribute to their realization. This would be up to the public management that does not care at all.

This analogue is certainly far from Italian healthcare, one of the best in the world and available to all citizens, although the establishment of the National Health Service in 1978 has always required, and will always require, remodelling to keep pace with the evolution of society. A society which is ultimately monitored by macroeconomic projections.

The world is indeed changing, and it is doing so at an ever-increasing speed. Migratory flows, for example, weigh on the system to such an extent that they risk collapse, and those in charge of health care must face and, above all, predict the most difficult and complex scenarios. Added to this is the increase in life expectancy, which is very positive in human terms, but which has a considerable impact on health budgets.

It is very important to monitor the impact of the global economy on national economies and the weight of wars, riots, famines, even if they're far away.

As for Italy, the alarm bells are many, and not attributable only to immigration: not infrequently, even for check-ups or medium-emergency interventions, the waiting times increase to an alarming extent. This fact, in addition to fueling the political controversy, is one of the signs of a situation that could worsen with time and with the increase of the population.

Added to this is the old and hateful comparison with private healthcare and with its very short waiting times. Furthermore, to reduce the gap one of the solutions most evoked is the involvement of private individuals in public healthcare. The problem is, however, to identify ways in

* Editor-in-chief UGHJ.

which new partners can make a profit from their investments. Since the situation requires technological innovation, Lomonaco points to private equity as an effective and rapidly developing tool.

The idea of equal care for all is a utopia, but good health policy worldwide is not always directly proportional to per capita income, and contradictions are not lacking. This is especially true if you think that, for example, the treaty which established the World Health Organization was signed in 1946 in New York, United States, where healthcare is private.

Contradictions aside, it is urgent to improve the objective situation that sees the health economy in the launch pad to be valued up to very high levels. As Federico Spandonaro writes, it is still too early to define it as an autonomous and specialized branch of the economy, but it could help to make the dialogue between healthcare systems so different around the globe a little less difficult.

A paradox, perhaps a dream: scientists, economists, managers could turn into positive the very rapid social transformations that seem to us a threat to health systems, even the most structured ones. By studying the changes and preventing them, it is possible to build a model ready to be integrated into the future.

Ultimately, it would be important to understand to what extent the National Recovery and Resilience Plan can act as a proper corrective mechanism for the system.

Brief reflections on the relationship between Economy and Healthcare (and Health)

by Federico Spandonaro*

Abstract
The paper proposes some reflections on the relationship between Health (and Healthcare) and Economy: after a brief historical examination of the development of institutional and academic attention to economic problems related to Health, it points out the aspects on which the clinical and economic approaches are assonant (e.g. for the decision-making criteria adopted) and those on which they are dissonant (e.g. in terms of paternalism of the approach).The paper then addresses the issue of the conflict between increasing scarce resources and growing needs, underlining the problems of equity that it implies, as well as providing an indication of the ethics used by economics to solve this trade-off.

Keywords
Health Economics, Healthcare Management, Equity.

Awareness that Health and Healthcare are issues that also involve economic problems seems widespread today, but it is a relatively recent phenomenon.

In a very conventional way, one can place the origin of an interest of the social sciences towards Health in the first post-war period. An "evocative" date is represented by 1948, date which marks the establishment of the WHO (World Health Organization), but also the birth, in the United Kingdom, of the first universal health service: the NHS (National Health Service).

We must wait a few more years to see Health Economics recognized as an "autonomous" and "specialized" branch of the Economy: it is equally conventional to trace the birth of *Health Economics* to the publication, in 1963, of the paper "Uncertainty and the Welfare Economics of Medical Care" by K.J. Arrow [1].

After all, the acquisition of this widespread awareness of the existence of significant economic and social impacts of Health/Healthcare can be traced back to a series of factors, difficult to sort by priority, that have contributed

* University of Rome Tor Vergata – C.R.E.A. Sanità.

overall to increasing the political and scientific attention on Health. Without claiming exhaustiveness, we mention:

1. the affirmation of the idea that the protection of health is an inalienable right and therefore linked to citizenship: it is a conquest of civilization, probably also promoted by the will to leave behind the horrors caused by world wars;
2. the spread of globalisation;
3. the rapid growth of scientific knowledge;
4. an awareness of the intrinsic complexity of the healthcare sector, which is the subject of Arrow's founding contribution.

The first point is that it has led to the establishment of international organizations dedicated to Health along with the first public health services. These brought about a revolution in the criteria of resource allocation in public budgets (in developed countries, Health is the second item of the public budget after social protection). As a consequence, an interest in the "macro-economic" impact of Health arose. The second point confirms the importance of a supranational governance of health problems, but also marks the economic interest for highly supranational industrial sectors, such as Life Sciences.

The third point is relevant because it has generated a huge growth of therapeutic opportunities (the incredible and fast extension of life expectancy is the confirmation of this), but also a rapid growth of the health budget.

The fourth point has quickly proved to be a strategic element: the complexity of health systems has confirmed to be really relevant, posing huge challenges to the definition of health policies, but also, at the micro level, to the management of health services.

The following decades have only confirmed the economic and social importance of the sector, demonstrating the existence of an inseparable link between health/healthcare and economic policies.

It is beyond the scope of this contribution to analyze almost a century of development of the economy and management of Health: it is enough here to mention the recent pandemic of Covid, to demonstrate how, as a result of globalization, beyond goods and people, today, pathogens are circulating with incredible speed, with no borders that can contain them and that require enormous efforts of coordination and economic investment. The pandemic, along with the decision to adopt the so-called lockdowns, has also confirmed that population health levels are, without doubt, an essential determinant of economic development. Not to mention the exponential growth in the cost of therapies: precision medicine and new therapeutic approaches (mention should be made of the so-called ATMP – Advanced Therapy Medicinal Products), have led to launch therapies on the market with treatment costs that exceed (in Italy) even two million euros per patient.

Together with the growth in costs, almost paradoxically, we are also witnessing a growing (and consequent) difficulty in producing evidence in terms of effectiveness and safety, necessary for the processes of market access, resulting in an explosion of the levels of uncertainty, and therefore of the complexity in the decision making process, already prophesied by Arrow.

On a practical level, the "encounter" between Econ-

omy and Health is certainly favoured by the fact that they are "twinned" due to a cultural approach that is largely overlapping.

Economic science is based on the principle of the need to make choices: according to M. Friedman the sense of economy can be summarized with the adage «There's No Such Thing as a Free Lunch», title of a famous 1975 book [2].

In other words, the Economy observes that every person, during his/her life, is continually called to make choices, and that these choices happen in a context of scarce resources; this last assumption, in some way axiomatic, is however pragmatically evident: this is because it does not stem from the consideration of scarcity in physical terms, but rather from the effects of allocation choices. In other words, it is easy to see that, in general, any resource can be used alternatively, and therefore any choice to use a resource for an end, also implies the renunciation of using it for another goal.

Each decision/choice is aimed at producing a benefit but, in a context characterized by "scarcity", this implies accepting a cost. In Economics, costs are simply the renunciation of lost opportunities by deciding to use resources in one way rather than another.

So the Economy studies how these choices happen, assuming that the subjects (people and/or organizations) decide rationally, in other terms try to maximize the benefits obtainable and, at the same time, minimize the costs.

In a more "formal" way, the Economy exemplifies the process of seeking well-being (utility in the economic lexicon) that characterizes human behaviour, assuming that it is based on the objective of maximizing the balance between benefits and costs (search for efficiency in the economic lexicon).

The previous, synthetic and rough, description of the foundations of economic theory, describes an approach that is largely similar to that practiced for centuries in the clinic, where the principle of maximizing the balance between benefits and risks is adopted.

Over the centuries, the "rule" has been established whereby medical intervention is aimed at maximising the benefits for the patient, while minimising the risks involved in any therapeutic choice.

It therefore seems evident that the cognitive map is substantially common in the two approaches.

To find some real difference between the two approaches, we must observe that, in the clinic, the benefits are those of the health of the single patient, while in economics they are more generally linked to the overall quality of life perceived by the patient (and perhaps his care-givers). Similarly, the risks in the clinic are those related to therapy, while the costs of economists are, more generally, all the "disutilities" linked to the renunciation of alternative opportunities. In other words, there seems to be no awareness of resource scarcity in the clinical "benefit versus risk" approach.

The overlap of the approach has certainly favoured the "interview" between the two disciplines, but its remaining differences have also been the basis of some risk of misunderstanding, with the increasing attribution of managerial responsibility to health professionals. In fact, they were asked to move from an "individualistic" approach, one to one, which is typical of the relationship between doctor and patient, to one that expands the perimeter of the alterna-

tives, setting the ambitious goal of maximizing social welfare. The need to overcome this "individualistic" approach has, however, provoked many resistances, placing professionals in a critical position towards the economic approach.

This resistance is also linked to the paternalism of the clinical approach, which has clashed culturally with the absolute absence of paternalism of the economic approach. While the clinician poses himself as "perfect agent" of the patient, able to make the choices that maximize his well-being, the economist "adapts" to the subjective choices of the patient, provided that he is supported by a complete information (axiom of consumer's rationality). To give a rough example, to the clinician the habit of smoking appears to be an evidently irrational choice, and as such to be countered; for the economist it is, instead, "not questionable", to the extent that the smoker is aware of the risks he runs. In this case, if the subject decides to smoke anyway, the Economy assumes that the benefit (pleasure) obtained from smoking has been estimated to be greater than the cost (risk) that it entails and, therefore, is to be considered a "rational" choice.

In any case, with the passage of time and the continuous interaction, many misunderstandings have been recomposed. Perhaps one exception is related to the "non-acceptance" of the axiom of "scarcity of resources" that, in the debates on Health, for some remains the subject of perplexity.

Moreover, it is clear to everyone that, at world level, Health is increasingly conditioned by the lack of financial resources. This might be for different reasons: if it is difficult to guarantee universal health protection in countries with lower economic resources, both because of a lack of resources and because of the growth of inequalities, in the richer countries, on the contrary, it is the growth of the therapeutic opportunities, and the relative costs, to have put the system into a "crisis" situation. This discrepancy between therapeutic opportunities and resources has imposed "uncomfortable" choices: specifically, it has led to a prioritization, more or less explicit, based on the contexts in which it is placed, of the health needs to be met.

Prioritisation, the result of scarcity, implies the risk of rationing and, therefore, has generated adverse reactions from a significant part of the health profession, as it is perceived as, substantially, immoral and/or the daughter of a bad policy (the evidence that the doctor must act according to "science and conscience" often goes against the need to take into account a budget).

In Italy, for example, priority has been given to the definition of LEA (Essential Levels of Assistance), that is to say, the services to be guaranteed to all citizens. LEAs, as explicitly stated by law [3], are economically conditioned, in the sense that they give citizen access to what is compatible with the sustainability of health services and the macro-economic balance of the country. In other words, in each jurisdiction the health service offers its "members" levels of protection commensurate with the resources at its disposal.

This conditioning has been counterbalanced in the legal field by the principle that there is an essential core of the right (to health protection), considered irreducible by the legislator [4].

How to frame such "essential nucleus" remains however a debated question, since the

satisfaction of the needs is tied to the supply of services. Moreover, these services imply a cost (in this case, first of all financial one), which makes the problem of having sufficient economic resources unavoidable.

This fact confirms, therefore, that Health and Economy are "inseparable". The slogan «rationalize not to ration», coined in the 1990s in support of the reform of the Italian National Health Service (I-NHS), and that referred to health services, remains a clear attempt to "remove" the moment when it becomes necessary to address the (difficult) issue of how sustainable the essential core of law is

In other words, the efficiency of health services has (also) become the way to avoid making (very) difficult decisions, as well as a way to perpetuate healthcare-related Welfare promoted in the twentieth century.

The ethical need to rationalize Health has increased the importance of the micro approach, defined as the Business Administration approach, applied to Health. Despite being much behind compared to other countries, from the 90s onwards also in Italy an important line of economic analysis has developed, and business management (of Health) has probably become a predominant element with respect to the classical themes of Health Economics (macro), as the fundamentals of health consumption choices, agency relations in relations between health professionals and consumers, risk aversion and insurance efficiency, causation relationships between health and development, between health and income, education and health, etc.) [cf. 5]. The academic focus has moved toward the structuring of administered markets, to the efficiency of delivery structures, and, successively, on the management of resources (human and non-human), etc.

The transformation of Local Health Units into (public) health companies is the most evident demonstration of the desire to draw attention to the efficiency of services.

Although, to the knowledge of the writer, an evaluation summary of the 30 years efforts to apply managerial logic to Health has not yet been formulated, it seems difficult to deny that they have had the merit of keeping health services "sustainable" by perpetuating the existence of health-related welfare.

Nevertheless, the application of the micro-economic approach, at least in specific cases such as the Italian one, may have fallen into error or, at least, into a misinterpretation of economic logics. For example, the spending review season, also called of the "linear expense cutting", is now subject to rethinking, and increasingly pointed out as a cause of a retreat of the Italian National Health Service.

In keeping with "observable" examples, we should simply consider the freeze in recruitment that has led to the now widely renowned shortage of staff. In alternative, we could consider the indiscriminate cutting of hospital beds, which has generated significant difficulties in accessing during the pandemic phase.

This aspect can be summarized by pointing out that prioritising the accounting aspect of the balance sheet has generated a trade off between technical and allocative efficiency, which risks producing short-term choices in contradiction with the pursuit of long-term efficiency.

In cultural terms it has also revived the aversion of

some towards the economic approach (renamed by others "economicistic") and the conviction of its immorality or at least a-morality, losing sight of the fact that efficiency implies instead the ethics of maximizing health produced with the available resources.

Before closing these brief reflections on the relationship between Economy and Health (healthcare included) one cannot avoid discussion on the role of the Economy in the event of reaching the point of "difficult choices". It is the right to the protection of health that we are forced to think about.

Although the legal approach seems to deny the existence of a shortage of resources that could conflict with the (essential) right to health protection, the economic approach cannot and does not want to renounce emphasizing that, although the assumption is considered axiomatic, the scarcity is factually incontrovertible. The question is, then, whether the economy can have its say in the event of a conflict between available resources and citizenship rights.

To answer this question it is necessary to broaden the definition of Economics, including in it the distributive elements that also regulate the aspect of equity, for example referring to the definition of economic science attributed to P. Samuelson: «Economics is the study of how people and Society choose, with or without the use of money, to employ scarce productive resources which could have alternative uses, to produce various commodities over time and distribute them for consumption now and in the future among various persons and groups of society».

The theme of the distribution of goods and services between people and generations (and Society) brings us into the field of Equity, a field dominated by cultural and value elements, and that undoubtedly remains between Economy and Politics.

Nevertheless (excluding the paradox of null resources) it seems to us that, if (hopefully never) the resources are not sufficient to guarantee to all citizens the services that are part of the essential nucleus of the law, the answer that an Economy, willing to confront the issues of Equity, should give could only be to make choices that reduce the differences of access: in other words, if it were necessary to make choices dictated by the impossibility of guaranteeing the essential in a universal way, the human costs of "no access" should be distributed equally, as suggested by the Rawlsian approach to social justice, with reference to primary goods [cf. 6].

The subject deserves a different kind of study, but it seemed appropriate here at least to include among the issues of the relationship between Economy and Health, the essential one of the government of the equitable aspects, which, moreover, are not universally recognized as a founding element of the economic approach.

In conclusion, in the preceding short reflections, we tried to provide some suggestion of the various economic approaches to the world of Health, starting from the most "macro" ones, to move to the micro-business-oriented ones, to return in conclusion on the equity aspects straddling Economics and Politics.

It has also been tried to argue that the relationship between Economy and Health, but also between Economy and Well-being, is inseparable and in some way primigenial. This does not exclude recognizing that improper uses of

economic logic, can generate contradictions and misunderstandings, with the consequent production of "antibodies" towards the approach.

The solution of potential antinomies must be found in the field of Health Policies, which should always aim to combine the demands (of the different stakeholders) of the health system. The debate on the effectiveness and efficiency of health policies, however, goes beyond the objectives of this contribution.

References

1. Arrow K.J. (1963), *Uncertainty and the Welfare Economics of Medical Care*, «The American Economic Review», vol. 53, issue 5, Dec. 1963, pp.941-973.

2. Friedman M. (1975), *There's No Such Thing as a Free Lunch*, Open Court Publishing Company, U.S.

3. D.lgs. 502/1992.

4. Corte cost., sentt. n. 309/1999, n. 252/2001, n. 354/2008, n. 282/2002.

5. Phelps C.E. (1992), *Health Economics*, Harper Collins, New York.

6. Rice T. (1998), *The Economics of Health Reconsidered*, Health Adm. Press, Chicago.

How private equity can drive innovation in the healthcare industry

Financing the future of global health

by Mario Mattia Lomonaco*

Abstract
Private equity is a topic that has attracted significant attention in recent years. This article investigates the rising trend of private equity involvement in the healthcare industry. Examining the factors driving this surge, it delves into the implications and potential shifts in the industry landscape. Supported by two compelling business cases, this analysis provides concrete examples illustrating the impact of private equity on the healthcare sector. Conclusions reveal that such investment brings with it both challenges and opportunities.

Keywords
Investment, Innovation, Technology, Opportunities.

1. Rising Private Equity activity in the healthcare industry

Private Equity (PE) is an alternative investment class that invests in or acquires private companies that are not listed on a public stock exchange. PE investors are active investors who provide their portfolio companies with bundles of value-added activities. The benefits can include increased growth (such as capital inflow, expertise, and access to new markets), improved profitability, (through operational changes and cost cutting measures), and enhanced shareholder value (higher valuation or public listing)[1]. PE players place a heavy emphasis on both their ability to select promising companies as well as their capacity to add value through financial means and industry knowledge.

In recent decades, PE activity in healthcare has exploded with financial institutions playing an increasingly important role in the sector. The healthcare private equity (HCPE) buyout deal value reached a record year with $151 billion in 2021. Yet even with the slowdown in the

* Student at Bocconi University, member of the Innovation in Health Chair at ESSEC Business School.

second half, 2022 was still the second-best year so far, with around $90 billion. This is in stark contrast with the less than $2 billion total deal value in 2001[2]. PE has been rapidly acquiring healthcare operators across different medical specialties, both throughout the US and beyond. The healthcare industry, renowned for its challenges arising from the involvement of various stakeholders, like patients, providers, investors, payers, and policy makers, offers plentiful potential investment opportunities.

2. Private Equity investments to spur innovation

The long-term growth of the healthcare industry is driven by several unchanging trends, including aging populations, the rise of chronic diseases and the increased demand for healthcare services. These factors, combined with the development of new technologies are driving innovation in healthcare, by improving the quality and accessibility of medical services, enhancing patient outcomes, and making the healthcare system both more efficient, and patient centered. These advancements are continually evolving, promising a future where healthcare is not only more effective but also more personalized and accessible to people around the world. Investors with confidence in this sector who can identify highly differentiated assets and possess the expertise to craft a strategy for operational excellence will be well-positioned for success.

Healthcare has historically underspent on technology. In Europe, an average of approximately 11% of gross domestic product (GDP) is spent on healthcare. Of this figure, around 7.6% is attributed to medical technologies[3]. The pandemic, however, has accelerated the digitalization of the healthcare industry and the sector has attracted huge inflows of private and public investments. Healthcare Information Technology (HCIT) reached its second-best year in deal count[4]. According to the HIMSS Future of Healthcare Report, 80% of healthcare companies plan to increase investment in technology and digital solutions over the next five years[5].

Healthcare providers are underinvested in IT, and this suggests an upside for future technology spending. According to Bain and KLAS's 2023 Healthcare Provider IT report, most healthcare providers are now prioritizing their investments into resource optimization software, such as revenue cycle management (RCM), patient intake/flow and electronic health records (EHR). Services that let healthcare providers "do more with less" now take center stage and PE investors can help such companies expand their solutions to serve their end markets more comprehensively[6].

PE also showed enthusiasm in services and technology that allow payers (from health insurance companies to third-party payers) to automate and improve efficiency about certain administrative functions. Businesses helping payers will receive significant funding to reduce operational complexity and solve a broad range of functional needs; in 2022 ClaimsXten, a claims management technology improving payment accuracy, was acquired for $2.2 billion by TPG.

Innovation and new solutions are also changing the Biopharma sector, as new digital tools accelerate clinical trials decentralization. Investors are therefore attracted by software and services companies

supporting clinical trials. Deal activity is increasing across all the pharma value chain including contract research organisations (CROs), contract development and manufacturing organisations (CDMOs), and commercialisation services. Investments in biopharmaceuticals are changing the clinical trial landscape, where further adoption of hybrid/decentralised strategies and more patient-centric approaches are expected to grow[7].

Besides the investment in IT, the development, design, and use of medical equipment to diagnose and treat medical conditions is continuously improving. The MedTech sector is receiving a lot of funding, especially towards original equipment manufacturers (OEMs), which provide best-in-class products with strong technological barriers (important deals in 2022 included 3D dental scanners and vascular intervention products). The OEM landscape is fragmented due to small and inefficient manufacturers. PE investing can bring valuable skillsets to the sector, by helping the industry to consolidate and create bigger companies that can take advantage of scale. Investors are also confident in long-term growth of medical aesthetic assets, such as injectable devices related to anti-aging, skin elasticity and fat-reduction procedures[8].

PE has also undertaken an important role in Life Science, where biomedical research and novel drug development are now relying more on genomic tools, such as next generation sequencing, and products that support faster and more accurate health assessment. With regards to the latter, artificial intelligence is accelerating therapeutic discovery, with new services emerging in patients screening through algorithm-based solutions.

3. Biomet case study: navigating a company through hard times

Once one of the most stable orthopedics companies, Biomet, a manufacturer of musculoskeletal medical products, went through hard times in 2006; the company was in turmoil, facing major issues with profitability and a public dispute. In the same year, the board announced that the company has been acquired by a group of PE investors formed by Blackstone, Goldman Sachs, KKR, and TPG. Biomet was taken private and delisted from the Nasdaq ("One of the great things about being private was that we didn't have to watch our value erode in the public market", J. Binder, the newly appointed CEO). Biomet's new investors committed to a long-term growth plan, which involved major changes in the current corporate strategy. Critical to the company's turnaround was re-establishing the long-standing culture of stability that had once defined the company. To do so, the focus was on capturing market share and developing innovative products. Biomet launched new sales force expansion programs and invested heavily in improving the functionality of its products through innovative engineering. PE investors played a crucial role in guiding the company through a very challenging period, which was further exacerbated by the 2008 global financial crisis. Notwithstanding these major strategic issues, Biomet's value increased over the seven-year PE ownership, and it was finally sold to Zimmer Holdings in 2014 for more than $13 billion. The merger created the second-largest manufacturer of orthopedics equipment and represented an important con-

solidation in the healthcare industry[9].

4. LifeScan case study: how its acquisition marked the "rebirth" for the company

Due to competitive pressures and price declines, in the first quarter of 2017 Johnson & Johnson (J&J) began a disinvestment of its Diabetes Care Companies: LifeScan Inc., Animas Corp. and Calibra Medical Inc. In October 2017, Animas Corporation exited the insulin pump market, while in 2018, Platinum Equity purchased LifeScan, J&J's subsidiary producing blood glucose meters, test strips and other digital health solutions, for $2.1 billion[10]. At the time of the deal, LifeScan was a leader in diabetes care, with $1.5 billion net revenue and about 20 million patients around the world using its products. Under the PE ownership, LifeScan introduced a new corporate brand identity, invested in digital solutions, and redefined its mission to provide customised health and wellness experiences to people with diabetes. LifeScan unveiled a new logo and announced partnership with Fitbit and Noom, companies with a digital focus. Val Asbury, CEO of LifeScan, said moving over to Platinum Equity was almost like the "rebirth" of the organisation. According to him, Platinum Equity brought their operational focus and helped LifeScan find where the inefficiencies were. They recognised the company's potential and committed to supporting its mission and vision[11]. LifeScan also partnered with local government to partake in community outreach, increasing awareness of diabetes and how to avoid it. On the environmental health side, it also launched strong initiatives around reducing carbon and water conservation. LifeScan also committed to becoming an environmental self-sustaining organisation by 2030.

5. Conclusion: Private Equity's controversial role

PE operates with a profit motive. This brings challenges for the healthcare industry, as concerns arise when patient welfare is combined with a business venture. Thus, there is a widespread sentiment that PE may be harmful to public health. This stigma is shaped by several factors[12]:

- Lack of transparency is a significant concern when it comes to PE investments, especially for sectors like healthcare. Limited disclosure and no public visibility on listed markets can make it difficult for stakeholders to assess the impact of PE ownership on patient outcomes and community access to services.
- The presence of players with limited knowledge in the industry. Investors that lack a deep understanding of healthcare complexities may struggle to make informed decisions that positively impact the quality of care.
- PE investments are of limited term (typically 3-7 years), as the goal is to generate return for the investors. However, the health of individuals and communities requires long-term investments, both in prevention and care provision

The arguments presented generate policy debates and new academic research. A well-renowned study published on the NBER suggests that PE acquisitions of nursing facilities lead to adverse health outcomes for some patients[13]. Notwithstanding these difficulties, it's critical to understand that PE

firms that invest in the healthcare sector can have a positive influence and that not all PE activity in the industry can be labeled as "bad". It's therefore important to recognise that PE investing brings with it both opportunities and challenges.

While many PE firms lack industry expertise, some focus solely on healthcare investments. Specialized teams of industry experts, including Ph.D. holders and medical doctors, are employed by PE funds, where they can apply their knowledge to the investment process. Healthcare-focused PE firms that employ experienced professionals can spot unique opportunities to unlock value. Most of these use "operating partners," who are often former CEOs of big corporations in the medical industry, who can bring decades of knowledge and operational know-how to the portfolio companies[14].

PE activity can also be beneficial for the healthcare industry by optimizing business operations. The LifeScan case shows that private investments were crucial in restructuring the company, via improved functionality of product and the streamlining of existing processes. The influx of PE capital can help struggling companies to properly allocate their resources as PE investors usually implement strategies to ensure that such resources are utilised optimally. By reorganising workflows and supporting companies to identify inefficiencies, PE can therefore make the delivery of healthcare services more efficient.

Zimmer Holding's acquisition of Biomet is an example of PE being a source of innovation for the healthcare sector, as well as facilitating mergers and acquisitions within the industry. When a PE firm buys a small medical device manufacturer, private capital can be used to adopt innovative technologies and practices. The acquired company can then become more competitive, and the PE firm will eventually sell it to larger players. In this sense, big conglomerates are beneficiaries of PE, as its activity in improving and innovating the company was crucial in making it an attractive investment. Ultimately, this is also vital for patients because hospitals and other operators are able to buy and use products otherwise unreachable.

Careful consideration and regulation are essential to ensure that the benefits of private equity investment in healthcare is realized without compromising patient well-being.

Notes and References

1. Dentons (2023), *Private equity's growing role in M&A has clear benefits*, https://www.dentons.com/en/insights/articles/2023/august/7/private-equitys-growing-role-in-m-and-a-has-clear-benefits.

2. Bain & Company (2023), *Global healthcare private equity and M&A Report 2023*, https://www.bain.com/globalassets/noindex/2023/bain_report_global_healthcare_private_equity_and_ma_2023.pdf.

3. European Federation of Pharmaceuticals Industries and Associations (2022), *The pharmaceutical industry in figures,* https://www.efpia.eu/media/637143/the-pharmaceutical-industry-in-figures-2022.pdf.

4. Bain & Company (2023), *Global healthcare private equity and M&A Report 2023*, https://www.bain.com/globalassets/noindex/2023/bain_report_global_healthcare_private_equity_and_ma_2023.pdf.

5. Healthcare Information and Management Systems Society (2021), *The 2021 future of healthcare report,* https://www.himss.org/resources/future-healthcare-report-exploring-healthcare-stakeholders-expectations-next-chapter.

6. Bain & Company (2023), *2023 Healthcare Provider IT Report: Doubling Down on Innovation,* https://www.bain.com/insights/2023-healthcare-provider-it-report-doubling-down-on-innovation/.

7. Davies N. (2021), *How biopharma and CROs can create value in a shift to decentralized trials*, https://www.ey.com/en_us/life-sciences/how-biopharma-and-cros-can-create-value-in-a-shift-to-decentralized-trials.

8. Bain & Company (2023), *Global healthcare private equity and M&A Report 2023*, https://www.bain.com/globalassets/noindex/2023/bain_report_global_healthcare_private_equity_and_ma_2023.pdf.

9. Invivo (2007), *Biomet's rebirth*, https://invivo.citeline.com/IV002987/Biomets-Rebirth.

10. Elvidge S. (2018), *J&J to sell Lifescan, dropping out of diabetes diagnostics*, https://www.biopharmadive.com/news/jj-to-sell-lifescan-dropping-out-of-diabetes-diagnostics/519401.

11. Platinum Equity (2021), *Why Platinum Equity acquisition of LifeScan was 'rebirth' for healthcare leader in glucose management*, https://www.platinumequity.com/news/why-platinum-equity-acquisition-of-lifescan-was-rebirth-for-healthcare-leader-in-glucose-management/.

12. Center for the business of health (2023), *Private Equity in healthcare: exploring the challenges and opportunities,* https://cboh.unc.edu/wp-content/uploads/2023/07/Private-Equity-in-Healthcare-07062023.pdf.

13. Atul Gupta, Sabrina T. Howell, Constantine Yannelis, Abhinav Gupta (2021), *Owner incentives and performance in healthcare: private equity investment in nursing* homes https://www.nber.org/papers/w28474.

14. American Investment Council (2022), *Improving medical technologies: private equity's role in life sciences* https://www.investmentcouncil.org/wp-content/uploads/2022/04/aic-life-sciences-report2-1.pdf.

The Italian National Recovery and Resilience Plan

Impact on the medical applications of ionizing radiation

by Marco D'Arienzo, Carlo Capotondi, Gian Marco Contessa*

Abstract
In recent years, the world has faced unprecedented challenges, such as the global pandemic and the subsequent strain on healthcare systems. In response, many countries have implemented recovery plans to address the impact of these crises. The Italian National Recovery and Resilience Plan is playing a vital role in addressing the challenges faced by the healthcare sector, particularly in the medical use of ionizing radiation. Ionizing radiation has long been crucial in diagnosing and treating various medical conditions. The present paper explores the impact of the Italian National Recovery and Resilience Plan on the medical use of ionizing radiation, highlighting its significance in improving patient care, enhancing safety standards, fostering research and development, and strengthening healthcare infrastructure.

Keywords
National Recovery and Resilience Plan (NRRP), Ionizing Radiation, Healthcare Radiological Equipment.

1. The National Recovery and Resilience Plan (NRRP) and its impact

The National Recovery and Resilience Plan (NRRP) is an ambitious and comprehensive plan developed by the European Union (EU) to address the economic and social challenges posed by the pandemic Covid-19. The plan sets out how EU countries will use funding from the NextGenerationEU initiative to support their economic recovery and build a more sustainable and resilient future. The reforms and investment in Italy's plan, approved by Council on 13 July 2021, as amended on 19 September 2023, are helping it become more sustainable, resilient and better prepared for the challenges and opportunities offered by the green and digital transitions.

Among other things, the National Recovery and Resilience Plan is bringing about significant improvements in patient care within the health sector. Increased funding is facilitating the acquisition of state-of-the-art equipment and the development of advanced imaging/therapy techniques. This will hopefully lead to

* Marco D'Arienzo, ASL Roma 6, Medical Physics Service, Saint Camillus International University of Health Sciences. Carlo Capotondi, ASL Roma 6, Diagnostic and Interventional Radiology. Gian Marco Contessa, Saint Camillus International University of Health Sciences.

more accurate and timely diagnoses, enabling physicians to provide more targeted and effective treatments. Additionally, the plan emphasizes the recruitment and training of skilled healthcare professionals, further enhancing the quality of care provided to patients. Improved access to radiology, nuclear medicine and radiation oncology services, reduced waiting times, and enhanced patient experience are some of the notable outcomes of this plan. In particular, the following areas will benefit from the investments envisaged in the National Recovery and Resilience Plan:

Replacement of outdated equipment that use ionizing radiation: the use of ionizing radiation technology in healthcare is progressing at an extraordinary and ever-accelerating pace. Radiology, radiotherapy, and nuclear medicine departments are able to improve both their standards of care and efficiency thanks to ongoing advancements. As part of the National Recovery and Resilience Plan, a significant focus has been placed on the replacement of outdated equipment that use ionizing radiation. This initiative recognizes the importance of having state-of-the-art technology in the field of radiology, radiation oncology and nuclear medicine to enhance patient care and diagnostic accuracy. Outdated equipment can lead to suboptimal image quality, longer examination times, and limited diagnostic/therapeutical capabilities. By allocating resources for the replacement of such equipment, the plan aims to improve the efficiency and effectiveness of radiological/nuclear medicine procedures and radiation therapy treatments. Upgrading to modern imaging systems, such as digital radiography, computed tomography (CT), and magnetic resonance imaging (MRI), not only enables faster and more precise diagnoses but also contributes to reducing patient waiting times and enhancing overall healthcare outcomes. Along the same lines, state-of-the-art radiotherapy equipment, such as advanced linear accelerators with image-guided radiation therapy (IGRT) and intensity-modulated radiation therapy (IMRT) capabilities, can deliver more targeted and precise radiation doses, sparing healthy tissues while effectively treating tumors.

The replacement of outdated radiological equipment under the National Recovery and Resilience Plan signifies a commitment to providing cutting-edge technology to healthcare providers, ensuring the delivery of high-quality care to patients.

Improved Safety Standards: one of the key focuses of the National Recovery and Resilience Plan is the enhancement of safety standards in the medical use of ionizing radiation. The plan emphasizes the implementation of strict protocols and guidelines to ensure the safe handling and administration of radiation in healthcare settings. Adequate training and education for healthcare professionals involved in radiation procedures are prioritized to minimize the risks associated with ionizing radiation exposure. By enforcing robust safety measures, the plan safeguards patients, healthcare providers, and the general public, mitigating the potential adverse effects of ionizing radiation.

Research and Development: the National Recovery and Resilience Plan recognizes the importance of fostering research and development in the field of medical use of ionizing radiation. Increased investment in

this area has led to significant advancements in radiation therapy techniques, such as intensity-modulated radiation therapy, stereotactic radiosurgery, and brachytherapy. These innovations have revolutionized cancer treatment, allowing for precise targeting of tumors while sparing healthy tissues. Additionally, the plan has supported research efforts to explore alternative applications of ionizing radiation in fields like nuclear medicine and molecular imaging, paving the way for future medical breakthroughs. Digital transformation is another important area where the NRRP can support healthcare innovation. Digital technologies such as artificial intelligence (AI) and machine learning can help radiologists interpret images more accurately and efficiently, enabling faster and more accurate diagnoses. Similarly, AI has the potential to improve the accuracy, precision, efficiency, and overall quality of radiation therapy for cancer patients. The NRRP includes investments in digital infrastructure, such as high-speed broadband connections, that can support the development and deployment of these technologies in healthcare.

Strengthening Healthcare Infrastructure: the National Recovery and Resilience Plan has allocated resources to strengthen the healthcare infrastructure related to the medical use of ionizing radiation. This includes the renovation and expansion of radiation oncology departments, radiology facilities, and nuclear medicine units. Upgraded infrastructure enables healthcare providers to meet the growing demand for radiation-based diagnostic and therapeutic services, ensuring timely access for patients. Additionally, the plan emphasizes the establishment of comprehensive radiation safety programs and quality assurance measures, fostering a culture of excellence and accountability in the delivery of radiation services.

Collaboration and Knowledge Sharing: the National Recovery and Resilience Plan encourages collaboration among healthcare institutions, research organizations, and industry stakeholders involved in the medical use of ionizing radiation. Collaborative networks promote knowledge sharing, research collaborations, and the dissemination of best practices. These partnerships facilitate the exchange of expertise, advancements, and quality assurance protocols, ensuring uniform standards and continuous improvement in the field. By fostering collaboration, the plan creates a dynamic environment that stimulates innovation and contributes to the development of new techniques and technologies.

Investment in resilience can help healthcare providers prepare for and respond to future crises such as pandemics or natural disasters, ensuring that essential imaging services remain available to patients.

2. A focus on the Italian National Recovery and Resilience Plan

Italy's recovery and resilience plan aims to address the urgent need for fostering a strong recovery and preparing Italy for the future in the wake of an unprecedented crisis brought on by the pandemic. Italy will become more resilient, sustainable, and well-prepared for the opportunities and challenges presented by the green and digital transitions thanks to the reforms and the investments in the plan.

The Italian NRRP was launched by the Italian gov-

ernment and approved by the European Union (EU) in April 2021. It aims to modernise the country's infrastructure and make it more resilient to future challenges. It includes a series of measures aimed at improving Italy's competitiveness, strengthening social cohesion and accelerating the country's transition to a more sustainable and digital economy. According to the Recovery and Resilience Facility Regulation, all reforms and investments must be implemented by August 2026.

The total NRRP includes funding of €191.5 billion, of which €68.9 billion is earmarked for investment and €122.6 billion for reform [1]. The plan includes 58 reforms and 132 investments to achieve this. The investments focus on six key areas (or missions), including digitalisation, sustainable infrastructure, green transition, education and research, social inclusion and health. These investments aim to boost economic growth, create jobs and improve the well-being of Italian citizens.

One of the main focuses of the NRRP is the healthcare system, with a significant amount of funding allocated to improving the quality of care and infrastructure in hospitals and medical facilities. The Sixth mission concerns health, a critical sector that has faced historic challenges in the past year. The impact of the Covid-19 crisis on health systems has demonstrated the importance of a full, equitable and uniform right to health across the national territory. Moreover, the pandemic has put personal well-being back at the centre of the political agenda. The reforms and investments proposed by the plan in this area have two main objectives: to strengthen the prevention and treatment capacity of the national health system for the benefit of all citizens to ensure fair and universal access to care, and to promote the use of innovative technologies in medicine. Mission 6 of the NRPP is divided into two components:

- M6C1: Proximity networks, facilities and telemedicine for territorial healthcare assistance. The measures of this component aim to strengthen the services provided in the territory by enhancing and creating local facilities and centers (such as Community Houses and Community Hospitals), strengthening home care, developing telemedicine, and more effectively integrating with all social and health services.
- M6C2: Innovation, research and digitalization of the National Health Service. The measures included in this component will allow the renewal and modernization of existing technological and digital structures, the completion and diffusion of the Electronic Health Record (EHR), a better capacity for providing and monitoring Essential Levels of Assistance (LEA) through more effective information systems. Significant resources are also allocated to scientific research and the propotion of technology transfer, as well as to strengthening the capabilities and human capital of the National Health Service through the improvement of human resource training.

The NRRP has allocated a total of 15.63 billion for the two components of the mission. Overall, Italy's NRRP can play a critical role in driving innovation and improving the quality of care in the use of ionising radiation in healthcare. By supporting investments in

digitalisation, sustainable infrastructure, health, resilience, education and research, and social inclusion, the plan can help healthcare providers deliver more accurate diagnoses and efficient therapies, reduce waiting times and improve outcomes for patients. The NRRP represents a significant investment in the future of medical use of radiation and has the potential to transform the field in the years to come.

3. Impact of NRRP in radiology

The Italian technological and digital hospital infrastructure is severely outdated and deficient in many facilities. The efficiency of the system and the quality of services are at risk, which could damage public confidence in the health system.

One of the most ambitious challenges of the NRRP is the modernisation of technological equipment in Italian hospitals, with an investment for the purchase of new high-tech equipment. As anticipated, €15.63 billion (representing 8.16% of the total) will be allocated to health (both M6C1 and M6C2 missions) to support significant reforms and investments for the National Health Service to be implemented by 2026.

A recent report by OASI shows an index of obsolescence of facilities and equipment in public hospitals at 79% [2]. Furthermore, according to Confindustria Medical Devices Observatory [3], which analysed the state of obsolescence of the diagnostic imaging technology park in Italian public and private healthcare facilities. As of 2021, nearly 37,000 diagnostic imaging devices in Italy were no longer aligned with the current level of innovation, with 95% of conventional mammography equipment beyond the update cycle, as well as 54% of nuclear magnetic resonances, 42% of CT scanners, and 51% of PET scanners (figure 1). A closer look at the differences in the geographic distribution of CT scanners, MRI scanners and mammography equipment is provided in figures 2-4, respectively. The PNRR envisages an investment to purchase and test at least 3,100 devices by the end of 2024 to replace the obsolete and unusable devices.

The planned investment of €4.05 billion simultaneously addresses three fronts to improve the technological equipment of the national health system and thus the quality of services provided. The measures are arranged as follows:

- the digital modernisation of the hospitals' technology park through the purchase of 3,133 new high-tech large-scale devices (CT scanners, MRI machines, linear accelerators, stationary radiology systems, angiography systems, gamma cameras, gamma camera/ CT scanners, mammography machines and ultrasound machines) older than 5 years;
- interventions aimed at increasing the level of digitisation of 280 health care facilities that are home to Emergency and admission wards (DEA) of level I and II;
- finally, the intervention (implementing Article 2 of Legislative Decree No. 34/2020) provides for the structural strengthening of SSN hospitals through the adoption of a specific plan to improve hospital services to ensure: (i) the increase in ICU bed capacity (+3.500 beds) to ensure the standard of 0.14 beds per 1,000 population and semi-intensive care (+4,225 beds); (ii) the consolidation of segregated pathways within the emergency department; (iii) an increase in the number of vehicles for secondary transport.

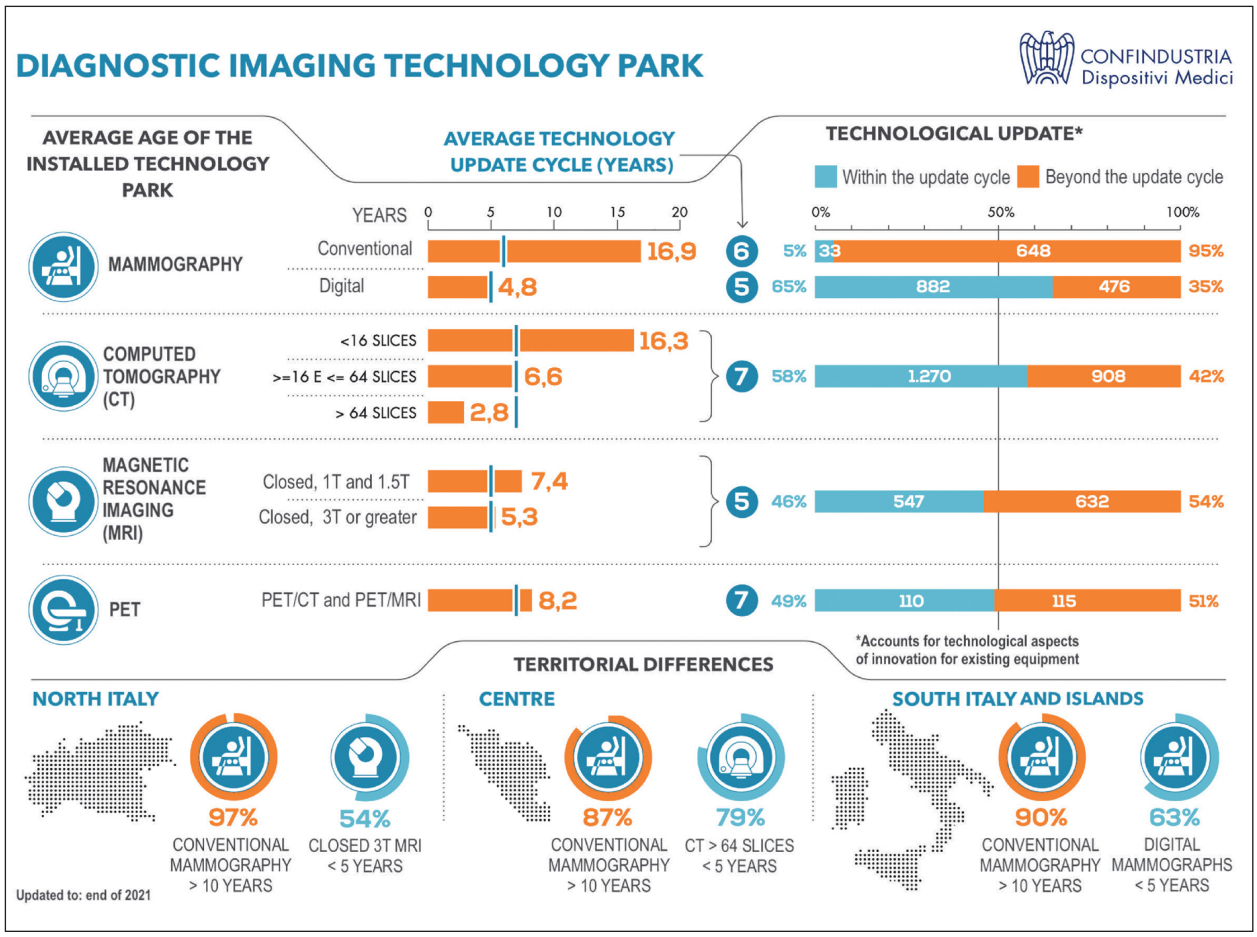
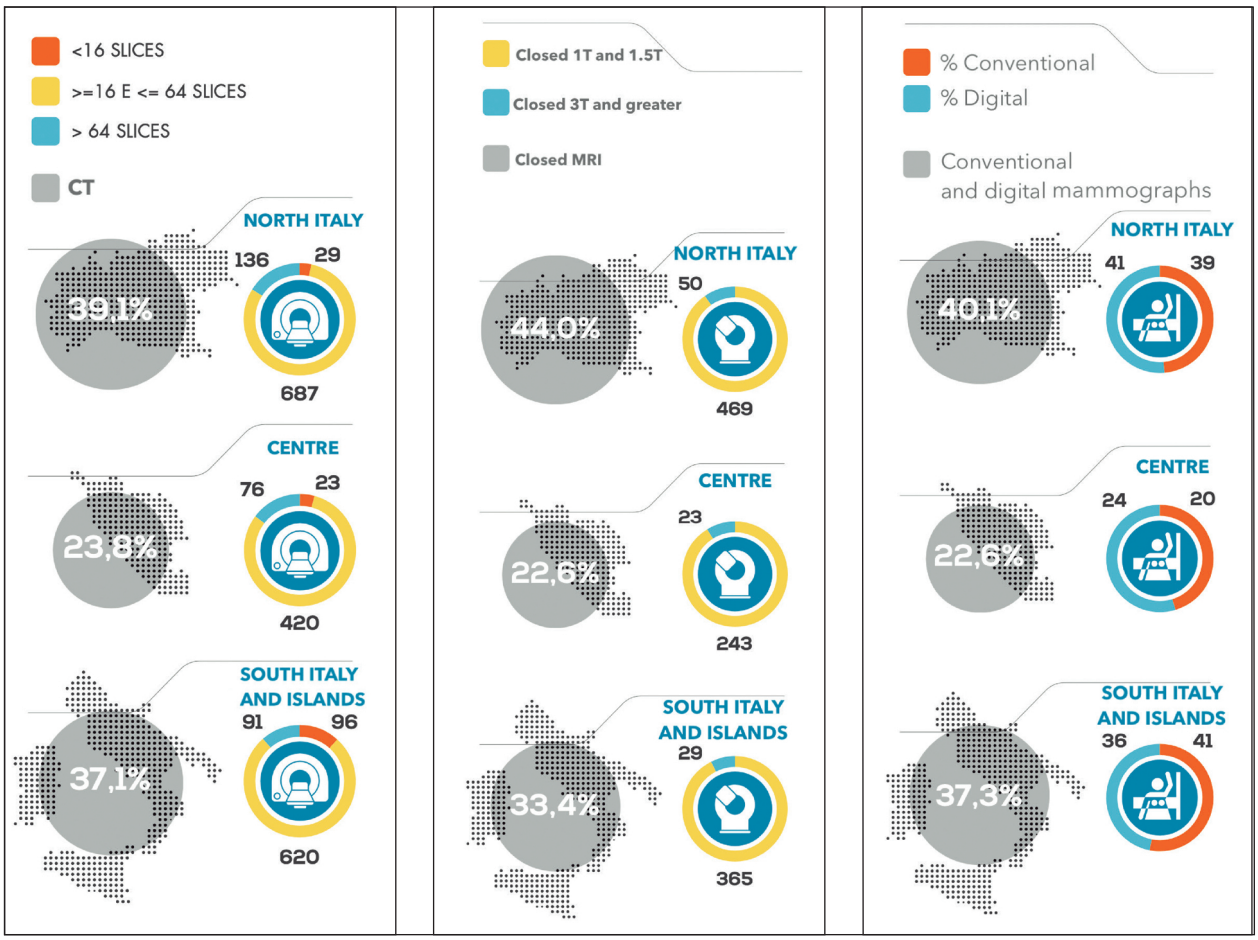


Fig. 1. Diagnostic imaging technology park in use at Italian public and private healthcare facilities in 2021, as reported by the Osservatorio parco installato (Opi) di Confindustria Dispositivi Medici. Source: https://www.confindustriadm.it/parco-installato-dati-2021/.

The total expenditure for the investment amounts to 4.05 billion euros. This amount also includes the share already included in the trend (and amounting to €1.41 billion) related to the projects already started by the Ministry of Health to structurally strengthen the SSN in the hospital sector, which are being prepared to deal with the Covid 19 emergency in accordance with the above-mentioned Article 2 of Legislative Decree No. 34/2020. Regarding the costs, the following can be said:

- Expenditure of 1.19 billion euros for the renewal of medical equipment. This expenditure relates to approximately €0.60 billion for the replacement of 1,568 pieces of equipment by the third quarter of 2023 and another approximately €0.60 billion for the replacement of the remaining 1,565 pieces of equipment by the end of 2024.
- Spending of €1.45 billion on the digitisation of Stage I and II DEAs (including €1.09 billion for the digitisation of 210 units by the first quarter of 2024 and €0.36 billion



Figg. 2, 3, 4. Distribution of 2,178 CT scanners (left image), 1,179 MR closed scanners (center image) and 2,039 digital mammography systems (right image) considered tobe in use by the end of 2021 in public and private healthcare facilities in Italy. Source: Osservatorio parco installato (Opi) di Confindustria Dispositivi Medici, https://www.confindustriadm.it/parco-installato-dati-2021/.

for the digitisation of a further 70 units by the end of 2025). The publication of the tender procedure and the signing of the contracts with the providers are expected for the third quarter of 2022.

– Total expenditure of € 1.41 billion by the second half of 2026 for the renewal of the existing ICU and semi-ICU bed capacities, the modernisation of the emergency rooms and the increase in the number of vehicles for secondary health transport (project already initiated).

The number and types of units to be replaced are: 340 CT (128 slice), 190 units of 1.5 T MRI systems, 81 linear accelerators, 937 stationary X-ray systems, 193 angiographs, 82 gamma cameras, 53 gamma cameras CT, 34 PET, 295 mammography units, 928 ultrasound units.

Every digital hospital should have a data processing centre required to computerise the entire hospital

structure, sufficient hardware and software IT technologies, electromedical technologies and additional technologies required to computerise each hospital department. The equipment will be installed where it is needed, depending on the purpose for which it is intended, the area where is to provide health care and the complexity of the diagnostic and therapeutic services it is required to provide.

The opportunity presented by the National Recovery Plan for the renewal of diagnostic imaging technology is unique and should not be wasted. However, a broader perspective is needed to take advantage of this opportunity. This means taking into account the actual needs and the appropriateness of the allocation, including the type of equipment. It is not enough to simply replace old equipment to do a good job. A health technology assessment is needed for rational and effective use of new technologies.

For example, regarding magnetic resonance imaging (MRI), for years Italy was in the upper part of the European rankings in absolute data on the number of technologies, while data on the number of examinations per inhabitant put the nation at the bottom of the average. It follows intuitively that the average utilisation rate of each device is low and well below the European average. In 2018, each MRI machine in Italy performed an average of 2,570 examinations, compared to 4,309 in Germany, 5,371 in Spain and 8,095 in France.

Therefore, regional analysis of imaging technology replacement should be carried out carefully and rigorously. The replacement of obsolete technology in a centre that performs significantly less than the benchmark may not be appropriate (the annual production of 4.000-8.000 MRI examinations is considered average [4]). On the contrary, it would be appropriate to concentrate technologies in centres that have adequate production capacity.

4. Impact of NRRP in radiation therapy

Oncology radiotherapy will also benefit from funding under the NRRP. Significant technological advances in oncology radiotherapy require upgrading of equipment, such as linear accelerators in Italian hospitals, which are often outdated and unable to provide the best treatment to patients.

According to a recent census of oncology radiotherapy centres and equipment in Italy, there are currently 430 external beam radiotherapy machines in operation, of which 377 are linear accelerators and 53 machines are capable of performing radiotherapy with highly complex technologies (30 machines for helical volumetric treatments, 17 machines for radiosurgery with Cyber Knife and Gamma Knife, four hybrid accelerators with magnetic resonance and two machines for proton therapy). Of these devices, 45.5% are older than 10 years and 29% are older than 12 years.

This need for modernisation has finally been recognised by the institutions, and the space dedicated to this topic in the National Rehabilitation and Resilience Plan is significant. The value of this investment is first and foremost one of equity. It is necessary to ensure that all Italian regions have the same capacity to provide treatment that meets international standards and uses the best possible technologies. In addition, hope journeys to distant places where the patient lives to receive the best and most

advanced treatment must be drastically reduced.

The situation is different for high-tech equipment for radiotherapy, which cannot be installed in all hospitals for cost reasons, but whose inclusion must be recognised organically in all regions on the basis of specific characteristics (such as expertise, treatment volume and other factors).

5. Impact of NRRP in radiation protection

As expected, the NRRP's measures include the purchase of about 3,000 pieces of hospital equipment to replace obsolete and out-of-service equipment. More than half of these (64%) will be equipment that uses ionising radiation and is therefore subject to the radiation protection provisions of Legislative Decree No. 101 of 31 July 2020.

As far as the implementation of this measure is concerned, there are unfortunately still significant delays in many regions. It is of utmost importance that the safety of radiological, radiotherapeutic and nuclear medicine treatments is guaranteed by organisational models that conform to the law and not only by state-of-the-art equipment.

With regard to radiological equipment, the recent Legislative Decree 101/2020 places particular emphasis on the role of the quality manual in a programme of continuous improvement of quality standards. In particular, the current legal framework prescribes the following measures:

- Indication of the absorbed dose class for patients following a radiological examination. According to Article 161, paragraph 6, each report must contain information on exposure to ionising radiation "consisting of an indication of the dose class (from I to IV) attributable to the examination in question". The dose class should be determined on the basis of the nature and methods of the radiological and nuclear medicine examinations and the indications given by the medical physics specialist.
- Quality manual and adopted standards. Article 164 requires the person in charge of the radiological establishment to draw up a quality manual containing "the standards adopted to verify the quality of radiological technique and diagnostic quality in radiodiagnostic procedures" (Annex XXVIII).
- Specific training for newly hired workers. "The employer shall ensure that each worker exposed to the risks of exposure to ionising radiation in the context of her/his assigned tasks receives sufficient and appropriate training in radiation protection, including any specific training" (Article 111). Such training is mandatory before newly recruited workers take up their duties.

6. Impact of NRRP in medical physics

Medical physics plays a vital role in radiology, radiation oncology, and nuclear medicine, contributing to the safe and effective use of radiation in these disciplines. In radiology, medical physicists ensure the optimal performance of imaging equipment, calibrate and maintain radiation dose levels, and implement quality control measures to ensure accurate and high-quality images. They also play a crucial role in dose optimization, ensuring that patients receive the necessary diagnostic information while minimizing radiation exposure of patient

staff [5]. In radiation oncology, medical physicists collaborate with radiation oncologists to develop treatment plans, calculate radiation doses, and ensure the precise delivery of radiation to cancerous tissues. They perform quality assurance checks on radiation therapy equipment, verify treatment accuracy, and monitor patient radiation doses. In nuclear medicine, medical physicists are involved in the safe handling and administration of radiopharmaceuticals, ensuring appropriate dosages and minimizing radiation exposure to patients and staff. They also contribute to image acquisition and analysis, ensuring accurate diagnostic information. Overall, the expertise of medical physicists in radiology, radiation oncology, and nuclear medicine is indispensable in providing safe and effective patient care, optimizing diagnostic accuracy, and ensuring the highest standards of radiation safety.

With this in mind, the Italian NRRP will have an unprecedented impact in the field of medical physics as well. The introduction of new technology utilizing ionizing radiation and the replacement of outdated equipment will require the establishment of robust quality assurance programs and the execution of acceptance tests on all new installations. Within the framework of the National Recovery and Resilience Plan (PNRR) and in compliance with the above mentioned Legislative Decree 101/2020, regarding the actions to be taken in various sectors of the medical physics specialist's expert activities, the following priorities can identified:

- In accordance with Article 163, Legislative Decree 101/2020, acceptance and performance testing must be carried out on all new installations utilizing ionizing radiation before they are put into operation.
- Development of new quality assurance protocols for medical radiological equipment implementing previously unavailable techniques or capable of executing new diagnostic/therapeutic protocols.
- Identification of medical radiological equipment compliant with the requirements established by the recent legislation (Legislative Decree 101/2020, Art. 163).
- Optimization of all radiological practices involving patient exposure, with particular attention to "Special Practices," as identified and defined in Article 165 of Legislative Decree 101/2020, namely all practices involving medical exposure of individuals: a) in pediatric age; b) exposed within screening programs; c) exposed within radiological practices involving high doses to the patient (as may occur in the case of interventional radiology, computed tomography, nuclear medicine) d) undergoing radiotherapeutic treatments.

7. Conclusions

The Italian National Recovery and Resilience Plan is currently having a significant impact on the medical use of ionizing radiation in Italy. Through increased funding, it has led to advancements in patient care, technological improvements, safety enhancements, and infrastructure development. These positive changes have resulted in improved diagnostic accuracy, enhanced treatment outcomes, and optimized patient experiences. The plan's commitment to investing in the medical use of ionizing radiation underscores the importance of delivering

high-quality healthcare services to the Italian population. By prioritizing enhanced patient care, safety standards, research and development, and healthcare infrastructure, the plan is likely to improve the delivery of radiation-based diagnostic and therapeutic services. As a result, the PNRR has positioned Italy at the forefront of medical advancements, ensuring the continued progress and success of the medical use of ionizing radiation in the country.

References

1. https://www.governo.it/sites/governo.it/files/PNRR.pdf (accessed on 5th May, 2023).

2. *Rapporto OASI 2019, Osservatorio sulle Aziende e sul Sistema Sanitario Italiano*, Centro di Ricerche sulla Gestione dell'Assistenza Sanitaria e Sociale (CERGAS) della SDA Bocconi School of Management Bocconi.

3. *Report Osservatorio Parco Installato 2021 (Opi)*, Confindustria Dispositivi Medici.

4. European Society of Radiology (ESR) (2014), *Renewal of radiological equipment*, «Insights into imaging», 5(5), pp. 543-546, DOI: https://doi.org/10.1007/s13244-014-0345-1.

5. Contessa G.M., De Crescenzo S.A., Rossi P. (2021), *The application of the optimization principle in the Italian and European context*, «Radioprotection», 56(3), pp. 199-204.

Availability of Linear Accelerators for Radiation Therapy treatments in Africa

Review of the literature and ideas for reflection

by Ahmed Hadj Henni*

Abstract
Radiotherapy is an essential modality in the curative or palliative management of patients with cancer. Its importance is further accentuated by the ever-increasing number of new cases. Unfortunately, linear particle accelerators (linacs), which are the reference equipment for carrying out radiotherapy care, are dramatically absent from a major part of Africa continent. Half of the countries on this continent simply don't have any. The aim of this work is to review the literature on the availability of this type of equipment in Africa. Some initiatives are highlighted in this document, in order to provide suggestions for reflection on this major issue of the quality of care in radiotherapy.

Keywords
Radiotherapy, Linear Accelerators, Health Crisis, Africa.

1. Brief overview of radiation therapy

Radiotherapy is one of the leading treatments in the fight against cancer, used alone or in combination with other therapeutic approaches (surgery, chemotherapy, hormone therapy, etc...). The principle consists of delivering a localized dose of ionizing radiation, quantified in Gray (Gy), to the malignant cells, sparing healthy cells as far as possible, since the latter have a greater capacity to repair the damage inflicted. Consequently, by multiplying the number of treatment fractions (fractionation) at an optimum dose, will make it possible to destroy diseased cells by blocking their capacity to multiply, and giving healthy cells time to repair themselves.

Radiotherapy is estimated to be involved in the treatment process of 45-55% of new cancer patients. It can be curative or palliative, to relieve the patient of the suffering caused by the tumor.

Irradiation is mainly delivered by MV (MegaVoltage) linear particle accelerators, the type and energy of which will depend on the location of

* Specialist in medical physics at the Frederic Joliot Center in Rouen, France.

the tumour. Other modalities, which are not discussed in this document, exist but MV accelerators are the most common.

2. General Data on cancer worldwide and in Africa in particular

The data presented here mainly come from GLOBOCAN 2020, published by the International Agency for Research on Cancer (IARC), the organization responsible for collecting and analyzing global cancer data [1].

The number of new cases in 2020 for all cancers combined, including both sexes and all age groups, is expected to be around 19 million. Men are slightly more affected than women, with 10 million and 9 million new cases respectively.

All populations combined, breast and lung cancers are the most frequent, accounting for 11.7% and 11.4% of new cases respectively. Colorectal cancer comes next with 10% of new cases, followed by prostate and stomach cancers with 7.3% and 5.6% respectively. For women, cervical cancer will account for 6.5% of the 9 million new cases in 2020.

To retain simple orders of scale, cancer is the first or second cause of premature death (i.e. deaths at ages 30-69 years) in 134 out of 183 countries, and the third or fourth in 45 others. According to the World Health Organization (WHO) [2], one in five men and one in six women worldwide will develop cancer during their lifetime, and one in six deaths worldwide is due to this disease, representing almost 10 million deaths by 2020. The total number of people living with cancer within five years after diagnosis, called as five-year prevalence, is estimated at 50 million.

Unfortunately, the projections announced for the next 10 to 15 years by international organizations are pessimistic [3]. The number of new cancers in 2040 is estimated at 28.4 million, representing an increase of over 40% compared to 2020. The aging and growth of the world's population, as well as changes in lifestyle habits explain this increase. The latter is itself unequal and will be strongly correlated with the economic development of each country.

Several indicators, such as the Gross National Income (GNI) per capita or the 4-tier Human Development Index (HDI) based on the United Nation's 2019 Human Development Report, enable to classify different geographic regions according to their socio-economic development. These two indexes are the ones most often used in the various studies consulted for this document.

Based on the World Health Organization's definition, GNI per capita is the dollar value of a country's final income in a given year, divided by its population according to the Atlas methodology. Countries are then divided according to their GNI per capita: low-income < 1046 US$, lower-middle income from 1,046 US$ to 4,095 US$, upper-middle income from 4,095 US$ to 12,695 US$ and high-income > 12,695 US$.

Figure 1 is a map showing the world's distribution into 4 categories: low, medium, high and very high income countries this time based on the calculation of the HDI index, more complex than the GNI, which takes into account life expectancy at birth, access to schooling and the GNI.

Analysis of the increase in cancer incidence can then be more closely linked to human development in a given country. The Word Health Organization (WHO) predicts that this increase is inversely proportional to GNI. More

precisely, between 2008 and 2030, the increase in cancer incidence is estimated at 82%, 70%, 58% and 40% in low, lower-middle, upper-middle and high-income countries respectively. As a reminder, radiotherapy will be required in the therapeutic care of 45-55% of new cancer patients.

Linear particle accelerators are the main delivery systems for ionizing radiation used in radiotherapy. The aim of this document is to review the literature on the availability of these devices on the African continent, which at the same time brings together the highest number of low and lower-middle income countries.

3. Availability of MV accelerators in Africa

The statistics presented in this section are mainly taken from the Directory of RAdiotherapy Centers (DIRAC) digital database [4], which lists radiotherapy centers and equipment around the world. This database, initiated by the International Atomic Energy Agency (IAEA), is constantly updated and provides access to an inventory of the material resources required for the practice of radiotherapy worldwide.

According to Elmore *et al.* [5] in their study on current MV machines resources in Africa and their estimate of needs for the coming decades taking into account GLOBOCAN 2020 projections: « no country had a capacity that matched the estimated treatment need. The message is clear.

DIRAC has registered 15,130 accelerators spread across 214 countries. The distribution is as follows: 9449 (62%) for High income (Hi), 4023 (27%) for Upper-middle income (UMi), 1615 (11%) for lower-middle income (LMi) and 40 (0.3%) for Low income (Li) countries. In 2020, only 430 units were available in Africa, half of which were installed in Egypt (119) or Southern Africa (97) [5]. Approximately half of African countries have no external beam radiation units for radiotherapy.

Today, the world's population is estimated at almost 8 billion, more than half of whom live in low or lower-middle income countries. Over 70% of these countries are located in Africa. These data should be set against the data from DIRAC [4] and Elmore *et al.* [5] on the availability of MV machines in these regions.

The IAEA has defined recommendations for the minimum equipment to be made available, in order to ensure proper patient care in radiotherapy. The objective to be achieved is 4 accelerators per million inhabitants. High-income countries reach 7.71 machines per million inhabitants. DIRAC also provides the results for the African continent: 1.12 for North Africa, 1.27 for South Africa and 0.08 for the rest of Africa. The statistics speak for themselves: 18 of these countries, with a population of over one million, are still without any radiotherapy facilities [6].

Christ and Willmann [6] in their recent study (2023) on global inequalities in radiotherapy more modestly estimate that: "the availability of a MVM per every 1 million inhabitants already helps to significantly reduce the cancer burden in LMICs" (Low and low-middle income countries).

These authors, taking up previous studies such as those by Levin *et al.* in 1999 [7], Wahab *et al.* in 2013 [8], Datta *et al.* in 2014 [9] and Elmore *et al.* in 2021 [5], outline the evolution of the situation in the countries with the most limited resources. Their findings are alarming: in 1999, 61% of African countries had no MV

accelerators at all; in 2013, this rate was 54%, rising to 52% in 2021. They rightly «point out that addressing these extreme health inequities remains a highly complex work in progress». To overcome this gap, Elmore *et al.* [5] estimate that between 1,500 and 2,000 treatment units would be needed in these low and low-middle income countries by 2030 to resolve these inequalities in care. According to the fairly consistent estimates in the various publications, this corresponds to 150 to 200 MV machines installed per year.

Moreover, it should be noted that the type of equipment needed to operate a radiotherapy center also requires multidisciplinary teams with strong medical and technical skills. This point is addressed by Christ and Willmann in their work. They estimate that African countries with low and low-middle incomes lack more than 500 radiation oncologists, 450 medical physicists, 900 radiation therapists and almost 400 nurses.

4. Few suggestions to get foward

No matter how modern an accelerator is, it involves a non-negligible investment cost ranging from 1 to several million USD for the most efficient. Jacob Van Dyk *et al.* in 2017 [10] carried out an analysis of the cost of setting up a radiotherapy center for the 4 regions (Hi, UMi, LMi and Li) defined by the Word Bank (http://data.worldbank.org).

In this study, the authors compare different scenarios, taking into account various operating parameters such as the number of treatment machines, the impact of the number of fractions per treatment, the irradiation technique used, the number of hours worked or the salaries of the various healthcare professionals. The results can then provide useful guidelines for optimizing local conditions. For their baseline scenario, of a center operating 8 hours a day with 2 MV accelerators, the annual operating cost is USD 4,595,000 for Hi countries versus USD 1,736,000 for Li countries. The difference is essentially due to salaries. MV machines are sold by manufacturers at approximately the same price in all countries. The authors then modulate the different parameters to compare to this reference operation. For example, it makes more sense to increase the size of the department up to 3 linacs than to operate with a single machine. Another example, reducing the number of working hours below 8 per day has a considerable negative impact on the cost per treatment.

Teleradiotherapy, in which a referent center takes charge of all pre-treatment steps and 2 satellite sites perform only the irradiation step, is discussed by Van Dyk *et al.* [10]. The latter compares this scenario with the installation of 4 totally independent radiotherapy centers. Their calculations show a 17% reduction in treatment costs for low-income countries. This strategy could provide solutions in countries where access to healthcare is mainly concentrated in big cities, and where large geographical areas are neglected.

The number of treatment fractions, whatever the tumor site, has a direct impact on the cost of patient management and the number of patients that can be scheduled per day. Hypo-fractionation means delivering a larger dose in fewer fractions than with a standard protocol. Obviously, this particular therapeutic regimen must achieve at least the same results in terms of treatment

efficacy and side effects as conventional fractionation. This is particularly the case for breast and prostate treatment.

Irabor *et al.* in 2020 [11], compared the two dose/fractionation schemes for these two cancers in terms of cost and access to care. The authors studied the potential benefits for Africa, country by country, of reducing breast treatment from 25 to 15 fractions, and prostate treatment from 35 to 20 fractions. Adopting a protocol with fewer fractions but higher doses could reduce total treatment costs by up to 40% and increase access to care by 30%. Calculated over 7 years, the cost reduction for the continent as a whole would be $2.7 billion.

In this document, only the aspect relating to MV treatment machines has been addressed. Clearly, to find solutions to this health crisis in Africa, many other points need to be taken into account. These considerations must be part of a national cancer plan. For example, improving prevention and diagnosis would reduce the burden of cancer on African countries. According to the World Health Organization, over 70% of female breast cancer cases in Africa are detected at very advanced stages of the disease. In this situation, no treatment can provide satisfactory results.

Ndlovu *et al.* [12] point out that in addition to the obvious improvements in terms of prevention, diagnosis, training and cost, socio-cultural aspects must also be considered. Quoting him: «There is a general lack of knowledge and fear of radiotherapy treatment by the public in Africa. This is largely driven by limited awareness and education on cancer, its causes and various treatment modalities. Some cultural practices may promote mysticism about cancer and its management that leads to reduced acceptance and uptake of radiotherapy as a standard form of cancer treatment. There is a common belief of linking cancer to spiritual issues such that the preferred default health seeking behaviours for cancer patients are those of looking to alternative rather than mainstream forms of treatment. Also, since patients present with late-stage disease, which is a cause of poor survival even with the best of interventions, fear of radiotherapy may stem from the association of the intervention with demise that may usually follow shortly after palliative radiotherapy treatment».

Finally, for the purposes of this study the African continent was considered as a whole, but disparities in access to healthcare between different countries can be very considerable. It would therefore be appropriate to consider more closely each geographical region.

5. Conclusion

The whole international community (rich countries, non-governmental organizations, charitable associations, etc...) has a role to play in finding solutions to this health crisis. However, the key actors are the Africans themselves, who know their own socio-cultural environment better than anyone else.

As a final reference, Ige *et al.* in an article published in 2021 [13], present a collaborative platform bringing together 28 African countries, all of which have at least one radiotherapy center, and also inviting several high-income countries. Initiated in 2016, their purpose has been to brainstorm accelerators prototypes that are more robust to more challenging local conditions. In particular, taking into account the instability of the power supply in these regions.

There are indeed many obstacles before achieving

the target defined by the World Health Organization for noncommunicable diseases (NCDs), of which cancer is one: «The Agenda sets the target of reducing premature deaths from NCDs by one third by 2030». However, many actors in Africa and outside are responding to this Herculean task with optimism and dynamism.

References

1. Wild C.P., Weiderpass E., Stewart B.W. (eds) (2020), *World Cancer Report: Cancer Research for Cancer Prevention*, Lyon, France, International Agency for Research on Cancer. Available from: http://publications.iarc.fr/586.

2. United Nations Development Programme (UNDP) (2019), *Human Development Report 2019. Beyond Income, Beyond Averages, Beyond Today: Inequalities in Human Development in the 21st Century*. Available from: hdr.undp.org/en/content/human-devel opment-report-2019 (accessed on 25th November 2020).

3. Sung H., Ferlay J., Siegel R.L., Laversanne M., Soerjomataram I., Jemal A., Bray F. (2021), *Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries*, «CA: A Cancer Journal for Clinicians», 2021 May, 71(3): 209-249, DOI: 10.3322/caac.21660. Epub 2021 Feb. 4. PMID: 33538338.

4. https://dirac.iaea.org/.

5. Elmore S.N.C., Polo A., Bourque J.M., Pynda Y., van der Merwe D., Grover S., Hopkins K., Zubizarreta E., Abdel-Wahab M. (2021), *Radiotherapy resources in Africa: an International Atomic Energy Agency update and analysis of projected needs*, «The Lancet Oncology», 2021 Sep., 22(9): e391-e399, DOI: 10.1016/S1470-2045(21)00351-X. PMID: 34478675; PMCID: PMC8675892.

6. Christ S.M., Willmann J. (2023), *Measuring Global Inequity in Radiation Therapy: Resource Deficits in Low- and Middle-Income Countries Without Radiation Therapy Facilities,* «Advances in Radiation Oncology», 2023 Mar. 1, 8(4): 101175, DOI: 10.1016/j.adro.2023.101175. PMID: 37008253; PMCID: PMC10050474.

7. Levin C.V., El Gueddari B., Meghzifene A. (1999), *Radiation therapy in Africa: distribution and equipment*, «Radiotherapy and Oncology», 1999 Jul., 52(1): 79-84, DOI: 10.1016/s0167-8140(99)00069-9. PMID: 10577690.

8. Abdel-Wahab M., Bourque J.M., Pynda Y., Iżewska J., Van der Merwe D., Zubizarreta E., Rosenblatt E. (2013), *Status of radiotherapy resources in Africa: an International Atomic Energy Agency analysis*, «The Lancet Oncology», 2013 Apr., 14(4): e168-75, DOI: 10.1016/S1470-2045(12)70532-6. PMID: 23561748.

9. Datta N.R., Samiei M., Bodis S. (2014), *Radiation therapy infrastructure and human resources in low- and middle-income countries: present status and projections for 2020*, «International Journal of Radiation Oncology, Biology, Physics». 2014 Jul. 1, 89(3): 448-57, DOI: 10.1016/j.ijrobp.2014.03.002. Epub 2014 Apr. 18. PMID: 24751411.

10. Van Dyk J., Zubizarreta E., Lievens Y. (2017), *Cost evaluation to optimise radiation therapy implementation in different income settings: A time-driven activity-based analysis*, «Radiotherapy and Oncology», 2017 Nov., 125(2): 178-185, DOI: 10.1016/j.radonc.2017.08.021. Epub 2017 Sep. 22. PMID: 28947098.

11. Irabor O.C., Swanson W., Shaukat F., Wirtz J., Mallum A.A., Ngoma T., Elzawawy A., Nguyen P., Incrocci L., Ngwa W. (2020), *Can the Adoption of Hypofractionation Guidelines Expand Global Radiotherapy Access? An Analysis for Breast and Prostate Radiotherapy*, «JCO Global Oncology», 2020 Apr., 6: 667-678, DOI: 10.1200/JGO.19.00261. PMID: 32343628; PMCID: PMC7193821.

12. Ndlovu N. (2019), *Radiotherapy treatment in cancer control and its important role in Africa,* «Ecancermedicalscience», 2019, 13, 942.

13. Ige T.A., Jenkins A., Burt G., Angal-Kalinin D., McIntosh P., Coleman C.N., Pistenmaa D.A., O'Brien D., Dosanjh M. (2021), *Surveying the Challenges to Improve Linear Accelerator-based Radiation Therapy in Africa: a Unique Collaborative Platform of All 28 African Countries Offering Such Treatment,* «Clinical Oncology (Royal College of Radiologists)» 2021 Dec., 33(12): e521-e529, DOI: 10.1016/j.clon.2021.05.008. Epub 2021 Jun. 9. PMID: 34116903.

The Nexus Between Healthcare Expenditure and Economic Growth in Kenya

by Maria Angela Wangui Maina*

Abstract
A robust healthcare system is widely acknowledged as contributing to economic development. Ergo, the relationship between healthcare spending and economic growth is a critical factor in achieving sustainable economic development in Kenya. This study aims to investigate the intricate relationship between healthcare expenditure and economic growth in Kenya, providing empirical evidence specific to the Kenyan context. It focuses on the analysis of healthcare expenditure trends, the efficiency of healthcare spending, and their subsequent impact on economic indicators in Kenya. Consequently, the results of this study hold significant implications for policymakers and stakeholders involved in shaping Kenya's economic and healthcare policies. By examining the relationship between healthcare spending and economic growth in Kenya, this study seeks to provide insights into the potential impact of healthcare investment on the country's economic development.

Keywords
Kenya, Healthcare Expenditure, Economic Development.

1. Introduction

The relationship between healthcare spending and economic growth is a critical factor in achieving sustainable economic development in Kenya. This basis is founded on Nobel laureate, Amartya Sen's work "Development as Freedom" where he emphasizes the importance of investing in human capabilities, including healthcare, to achieve sustainable development, and in turn, economic growth feeds back into improving general living standards, such as greater opportunities for people to become healthier, eat better and live longer[1].

Kenya faces significant challenges in balancing healthcare spending with economic growth[2]. Its health system is underfunded, with a population health expenditure of only 3% of the Gross Domestic Product (GDP), which is lower than the African average of 4.8%[3]. Previous studies on the impact of healthcare spending on economic growth in Kenya have shown mixed results, with some studies finding a positive relationship between healthcare spending and economic growth, while

* Consultant at Pavia e Ansaldo studio legale.

others reporting insignificant effects[4]. For instance, the positive relationship is noted by R. Kwak (2009) study, where he found healthcare expenditure results in positive economic growth[5]. K.O Kimanzi (2022) states, as government health expenditure plays a significant role in growth of economies by over 30% irrespective of level of income of each country[6]. The veracity of these findings are evident Kenya and Botswana in 1960, when both States had similar levels of per capita income and spent approximately 9% of their GDP on health and education over the next three decades, however, by 1990, Kenya had only grown 1.6% annually, while Botswana grew 6.5% annually – attributed to Botswana spending five times as much as Kenya on health and education[7].

This research article aims to investigate the intricate relationship between healthcare spending and economic growth in Kenya, providing empirical evidence specific to the Kenyan context. The importance of a robust healthcare system in fostering economic development is widely acknowledged, and this study seeks to provide insights into the potential impact of healthcare investment on the country's economic development.

This research article aims to contribute to the ongoing discourse on the importance of healthcare investment in driving economic growth in Kenya by providing a comprehensive analysis of the relationship between healthcare spending and economic growth in the country. The analysis will focus on healthcare expenditure trends, the efficiency of healthcare spending, and their subsequent impact on economic indicators. The findings of this study hold significant implications for policymakers and stakeholders involved in shaping Kenya's economic and healthcare policies.

By examining the relationship between healthcare spending and economic growth in Kenya, this research article seeks to provide insights into the potential impact of healthcare investment on the country's economic development. The study will contribute to the existing literature on this important topic, offering a deeper understanding of the dynamics of healthcare investment in the Kenyan context and offering recommendations for policymakers and stakeholders to enhance the impact of healthcare spending on economic growth.

2. Trends and efficacy of healthcare spending

The trends and efficacy of healthcare spending are critical factors in understanding the relationship between healthcare spending and economic growth in Kenya.

The trend of healthcare expenditure in Kenya has been characterized by a gradual increase in recent years, reaching 346 billion Kenyan Shillings (KSh) in Financial Year (FY) 2015/16, a 27.7% increase from KSh 271 billion in FY 2012/13[8]. In addition, the per capita expenditure in the United States Dollar (USD) has increased from KSh 6,602 (USD 77.4) in FY 2012/13 to KSh 7,822 (USD 78.6) in FY 2015/16 due to the weakening of the Kenyan Shilling[9]. Healthcare spending in Kenya is expected to be 4.24% of GDP by 2023, with healthcare spending per capita projected to be €4.39 billion Euros by 2023[10].

Despite the increase in healthcare spending, Kenya's health system remains underfunded, with a population health expenditure of only 3%

of the GDP, lower than the African average of 4.8%[11]. This low level of healthcare spending has contributed to significant health indicators that hinder growth, such as:

1. A high maternal mortality rate[12] due to inadequate healthcare investment that leads to women's deaths, hence reducing productivity and negatively impacting the economy further[13]. Consequently, this high rate can lead to increased healthcare costs, as women may require additional medical care and support due to complications from pregnancy and childbirth[14].
2. The burden of Non-Communicable Diseases (NCDs)[15] like diabetes and cancer which are a common cause of death and disability in Kenya. NCDs can cause increased demand for health services, leading to high costs of treatment and pressure for increased public health spending[16]. These diseases can also lead to productivity losses via premature mortality, early labor force exits, absenteeism, and work at lowered capacity[17]. The economic impact of NCDs on healthcare budgets and national income is substantial, with NCD-related health costs varying across countries, regions, and according to the type of NCD[18]. Households with NCDs in lower middle-income countries (LMICs) spend more on healthcare and are at greater risk of catastrophic expenditure and impoverishment[19].

Previous studies have shown that healthcare spending can have a positive impact on economic growth in Kenya[20]. However, the efficacy of healthcare spending in Kenya has been questioned, with concerns about the efficiency of healthcare spending and the allocation of resources[21]. The Kenyan government has made efforts to improve the efficiency of healthcare spending, such as implementing program-based budgeting (PBB) and increasing the use of technology in healthcare delivery[22].

3. Impact on economic indicators

The impact of healthcare spending on economic growth in Kenya is complex and multifaceted, with various economic indicators affected by healthcare investment. Recall the aforementioned studies have shown that healthcare spending can have a positive impact on economic growth in Kenya[23]. However, the efficacy of healthcare spending in Kenya has been questioned, with concerns about the efficiency of healthcare spending and the allocation of resources[24].

The impact of healthcare spending on economic indicators in Kenya is critical for policymakers and stakeholders involved in shaping the country's economic and healthcare policies.

Below are some examples of the impact health expenditure on economic indicators in Kenya:

1. The K.O Kimanzi (2022) study on the relationship between government health expenditure and economic growth in Kenya found that government health expenditure partly explains changes in economic growth[25]. The study estimated the impact of government health spending on economic growth and found a positive and significant relationship between the two[26].
2. The M. Nyamwange (2012) study recommends that the government should effi-

ciently allocate a substantial amount of budget funds to the health sector, given that health expenditure necessitates a substantial amount of economic growth[27].

4. Policy implications

From the above sections, inadequate health care expenditure in Kenya contributes to the slow economic growth rate, causing the need for measures to improve health care expenditure[28]. Policy plays a crucial role in healthcare expenditure for economic growth in Kenya. Policies aim to increase budgetary allocation to the health sector, enhance service delivery, and improve health outcomes, which are essential for economic growth and development in Kenya.

The challenges and opportunities for future spending on health in Kenya, as highlighted in the 2022 World Bank Kenya Public Expenditure Review, underscore the need for efficient allocation of budget funds to the health sector, given that health expenditure necessitates a substantial amount of economic growth – a feat which can only be achieved by effective policies[29]. The improvement of the health sector in Kenya is crucial for addressing the country's major socio-economic and health challenges. The government's high priority on the improvement of the health sector, as evidenced since the country's independence, reflects the ongoing efforts to enhance the health system and its impact on the economy[30].

The 2022 World Bank Kenya Public Expenditure Review further provides the following key policy recommendations for improving healthcare spending, in line with the findings of this study:

Continue protecting spending on social sectors, including healthcare, within the context of tight fiscal circumstances and increased resources over the medium and long term as the economy grows[31].

Tackle inefficiencies within the health sector and increase the value for money of public spending by prioritizing quality primary health care services over highly specialized health services at the hospital level, and reducing inputs-related inefficiencies, such as human resource competencies, medical equipment, and medical supplies[32].

Strengthen health resource management systems, address challenges related to health resource human motivation and retention and increase health resource skills and capabilities through competency-based training models, professional development, and adequate medical supplies and equipment[33].

Continue prioritizing investments in disadvantaged geographic areas and population groups to narrow socio-economic inequalities. Collect and monitor data disaggregated by socio-economic characteristics to better tackle inequities in access to and use of quality healthcare and health outcomes[34].

Implement strategies to improve budget execution, absorption of development budget, and disbursement of funds[35].

5. Conlcusion

The healthcare spending trends in Kenya have shown a gradual increase in recent years, but the health system remains underfunded, with a population health expenditure lower than the African average. This has led to significant health challenges, such as high maternal mortality rates and the burden of Non-Communicable Diseases (NCDs), im-

pacting both the health of the population and the country's economic productivity. While previous studies have shown a positive relationship between healthcare spending and economic growth in Kenya, concerns about the efficiency of spending and resource allocation persist.

In essence, the nexus between healthcare expenditure and economic growth in Kenya is multifaceted and requires a holistic approach. The findings of this research hold significant implications for policymakers and stakeholders involved in shaping Kenya's economic and healthcare policies. As Kenya strives for sustainable economic development, a concerted effort to optimize healthcare spending, address inefficiencies, and prioritize health outcomes is imperative. The path forward involves implementing evidence-based policies that align healthcare investment with broader economic development goals, thereby creating a healthier, more productive, and economically vibrant Kenya[36].

Notes

1. Sen A. (1999), *Development as Freedom*, Oxford University Press, Oxford.

2. Meng X., Mu G., Tong J. (2022), *Health economics in Africa from 1991 to 2020: A systematic review*, «Journal of Public Health in Africa», 13(2), DOI: https://doi.org/10.4081/jphia.2022.2027.

3. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY 2019/20,* p. 40, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

4. Kimanzi K.O (2022), *The Relationship Between Government Health Expenditure and Economic Growth: An Analysis of Kenya 1975-2020,* University of Nairobi, http://erepository.uonbi.ac.ke/handle/11295/163579; Misango K.M., Siele D. R., & Kemboi D.K. (2022), *Assessment of Government Health Expenditure and Economic Growth in Kenya*, «Jurnal Bisnis, Manajemen, Dan Ekonomi», 3(2), pp. 65-74, DOI: https://doi.org/10.47747/jbme.v3i2.738.

5. Kwak R. (2009), *The relative role of public and private health expenditure for economic growth: A Solow growth model expansion,* Vanderbilt University, https://ir.vanderbilt.edu/handle/1803/10287.

6. Kimanzi K.O. (2022), *The Relationship Between Government Health Expenditure and Economic Growth: An Analysis of Kenya 1975-2020,* University of Nairobi, p. 20, http://erepository.uonbi.ac.ke/handle/11295/163579.

7. Department for International Development, *Growth: Building Jobs and Prosperity in Developing Countries*, OECD, https://www.oecd.org/derec/unitedkingdom/40700982.pdf (accessed on 20th December 2023).

8. Ministry of Health (2019), *Kenya National Health Accounts FY 2015/2016*, Health Policy Plus, p. 16, http://www.healthpolicyplus.com/ns/pubs/16339-16616_KenyaNHAmainreport.pdf (accessed on 20th December 2023).

9. *Ibidem.*

10. Statista (2023), *Health Financing – Kenya*, https://fr.statista.com/outlook/co/health-indicators/health-financing/kenya (accessed 20th December 2023).

11. Nyamwange M. (2012), *Economic Growth and Public Health Expenditure in Kenya*, University of Nairobi, https://mpra.ub.uni-muenchen.de/43707/1/MPRA_paper_43707.pdf.

12. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY 2019/20,* p. 18, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

13. Pan American Health Organization, *Economics of NCDs*, https://www.paho.org/en/topics/economics-ncds (accessed on 20th December 2023).

14. *Ibidem.*

15. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY 2019/20,* p. 18, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

16. Pan American Health Organization, *Economics of NCDs*, https://www.paho.org/en/topics/economics-ncds (accessed on 20th December 2023).

17. *Ibidem.*

18. Muka T., Imo D., Jaspers L., Colpani V., Chaker L., van der Lee S.J., Mendis S., Chowdhury R., Bramer WM., Falla A., Pazoki R., Franco O.H. (2015), *The global impact of non-communicable diseases on healthcare spending and national income: a systematic review*, «Eur J Epidemiol», Apr. 30(4), pp. 251-277, DOI: 10.1007/s10654-014-9984-2.

19. Murphy A., Palafox B., Walli-Attaei M., *et al.* (2020), *The household economic burden of non-communicable diseases in*

18 countries, «BMJ Global Health», 5(2), DOI: https://doi.org/10.1136/bmjgh-2019-002040.

20. Kimanzi K.O. (2022), *The Relationship Between Government Health Expenditure and Economic Growth: An Analysis of Kenya 1975-2020*, University of Nairobi, p. 19, http://erepository.uonbi.ac.ke/handle/11295/163579.

21. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY2019/20*, p. 72, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

22. *Ibidem*, p. 38.

23. Kimanzi K.O. (2022), *The Relationship Between Government Health Expenditure and Economic Growth: An Analysis of Kenya 1975-2020*, University of Nairobi, http://erepository.uonbi.ac.ke/handle/11295/163579; Misango K.M., Siele D. R., & Kemboi D.K. (2022), *Assessment of Government Health Expenditure and Economic Growth in Kenya*, «Jurnal Bisnis, Manajemen, Dan Ekonomi», 3(2), p. 65, DOI: https://doi.org/10.47747/jbme.v3i2.738.

24. Aboubacar B., Xu D. (2017), *The Impact of Health Expenditure on the Economic Growth in Sub-Saharan Africa*, «Theoretical Economics Letters», pp. 615-616, DOI: 10.4236/tel.2017.73046.

25. Kimanzi K.O. (2022), *The Relationship Between Government Health Expenditure and Economic Growth: An Analysis of Kenya 1975-2020*, University of Nairobi, p. 19, http://erepository.uonbi.ac.ke/handle/11295/163579.

26. *Ibidem*.

27. Nyamwange M. (2012), *Economic Growth and Public Health Expenditure in Kenya*, University of Nairobi, https://mpra.ub.uni-muenchen.de/43707/1/MPRA_paper_43707.pdf.

28. Misango K.M., Siele D. R., & Kemboi D.K. (2022), *Assessment of Government Health Expenditure and Economic Growth in Kenya*, «Jurnal Bisnis, Manajemen, Dan Ekonomi», 3(2), p. 65, DOI: https://doi.org/10.47747/jbme.v3i2.738.

29. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY 2019/20,* p. xiii, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

30. Mohajan H.K. (2014), *Improvement of Health Sector in Kenya*, «American Journal of Public Health Research», 2(4), pp. 159-169, DOI:10.12691/ajphr-2-4-6.

31. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY 2019/20,* pp. xii-xiv, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

32. World Bank (2022), *Kenya Public Expenditure Review for the Health Sector FY 2014/15-FY 2019/20*, pp. xii-xiv, https://documents1.worldbank.org/curated/en/099150006242224188/pdf/P175146046aa000170926707583dac4738d.pdf.

33. *Ibidem*.

34. *Ibidem*.

35. *Ibidem*.

36. *Ibidem*.

Health 4.0 as a Key Enabler of Society 5.0

by Oleg Missikoff*

Abstract
Society 5.0 envisions a transformative future by seamlessly integrating cutting-edge technologies into the fabric of society, fostering a human-centric, sustainable, and intelligent ecosystem. This position paper explores the pivotal role of Health 4.0 as a key enabler of Society 5.0. Health 4.0, an amalgamation of AI, robotics, IoT, and big data analytics, revolutionizes healthcare delivery. Telemedicine, precision medicine, preventive medicine, and regenerative medicine applications are examined, highlighting their contribution to a proactive, personalized, and accessible healthcare landscape. The paper addresses challenges, proposes strategies, and outlines future directions for Health 4.0, emphasising its potential to revolutionise healthcare and advance the vision of Society 5.0.

Keywords
Health 4.0, Society 5.0, Artificial Intelligence, Digital Twin.

1. Navigating Society 5.0: A Visionary Journey

The concept of Society 5.0 was introduced by the Japanese government in 2016 and materialized as a visionary blueprint for the future. This ground-breaking initiative advocates for a more effective integration of cutting-edge technologies, particularly artificial intelligence, into the very fabric of our societal framework [1].

Rooted in the tangible manifestations of the Fourth Industrial Revolution (4IR), Society 5.0 was first unveiled by the Japanese Government's Cabinet Office's Council for Science, Technology, and Innovation. This revelation occurred within the context of the 5th Science and Technology Basic Plan, as articulated by the late Japanese Prime Minister Shinzo Abe in 2019 [2] [3].

At its core, this approach envisions a human-centric society that seamlessly harmonizes economic progress with the resolution of societal challenges through the integration of cyberspace and physical space, now defined in the scientific literature as "cyber-physical systems" [4].

* MLitt, PhD. Sapienza University, Rome, Italy. Earth 3.0 Foundation, London, UK.

The overarching goal of Society 5.0 is to empower every individual within our society to lead a life that is safe, secure, comfortable, and healthy. Simultaneously, it aspires to allow individuals to manifest their desired lifestyle. This transformative social endeavour seeks to establish a progressive society transcending the current sense of stagnation, fostering mutual respect, breaking generational boundaries, and enabling everyone to lead an active and fulfilling life.

Historical Framework

The genesis of Society 5.0 stems from the ambition to craft a fifth societal paradigm by optimising digital transformation. This evolutionary journey traces through four societal stages, each characterised by increasingly complex socio-economic models:

1. *Society 1.0 (Subsistence Economy)*: in Society 1.0, humanity's foundation rested on hunting and gathering, addressing basic needs for food and shelter. This egalitarian stage, existing for most of our evolutionary history, displayed profound adaptability to the natural environment but was limited by technological constraints.
2. *Society 2.0 (Surplus Economy):* Society 2.0 shifted to farming and breeding, enabling surplus production and allowing the accumulation of resources. The availability of more food than necessary led to the creation of specialized professions such as crafts and trade, with the related circulation of models and ideas. At the same time, however, the storage of resources and the need to defend them required the creation of armies managed by centralized powers and led to the emergence of social classes and inequalities.
3. *Society 3.0 (Industrial Economy):* Society 3.0 marked a transition to industrialization, leveraging technology across various fields. Factories and machinery transformed economies, leading to urbanization and further specialization. The surplus economy exploded, sustaining larger populations but introducing new challenges like environmental exploitation.
4. *Society 4.0 (Information Economy):* the advent of Society 4.0 ushered in an information-centric era. Here, the significance of information and communication technologies progressively shifted the focus from goods to data and is profoundly reshaping societies. Personal computers, the Internet, smartphones, and other technological advancements, such as artificial intelligence (AI), automation, and robots became catalysts for industrial and societal innovation, transforming lifestyles and work dynamics.

Society 5.0 for SDGs

Japan's National Institute of Advanced Industrial Science and Technology identified six fundamental technologies crucial for realizing Society 5.0. These include enhancing human capabilities within Cyber-Physical Systems, AI hardware technology, self-developing security technology for AI applications, efficient network technology, next-generation manufacturing system technology, and measurement technology tailored for digital manufacturing processes. Additionally, the Japan Business Federation (Keidanren) aligned "Society 5.0 for SDGs" with the United

Nations' Sustainable Development Goals, underscoring the compatibility between Society 5.0 and the SDGs [5]. This convergence represents a crucial stride towards a future where technology seamlessly intertwines with societal needs and global sustainability objectives.

2. Health 4.0: Digital Technologies for Patient-Centric Healthcare

At the core of progressive healthcare practices lies the integration of the Health 4.0 framework, leveraging digital technologies to reshape the landscape of medical care. Within this paradigm, precision medicine emerges as a cornerstone, tailoring interventions to individual patients and advancing the efficiency and precision of healthcare delivery. This marks a significant leap forward in the evolution of healthcare systems, transcending traditional approaches [6].

Integrating P4 Medicine, Systems Medicine, and Inclusive Medicine

Guided by the principles of P4 medicine (predict, prevent, personalize, and participate), systems medicine, and inclusive medicine, Health 4.0 represents a fundamental transformation in healthcare. Embracing holism, Health 4.0 conscientiously evaluates all aspects of an individual's life, integrating non-linear and multidimensional information to develop personalized treatment modalities. This comprehensive perspective aims to catalyse a paradigm shift, offering tailored, patient-centric interventions that consider the intricate interplay of diverse determinants shaping an individual's health and well-being [7].

In this work, P4 Medicine is augmented through the strategic integration of two pivotal dimensions: "pervasiveness" and "persistence", "Pervasiveness" strategically embeds healthcare technologies into daily routines, amplifying their reach and accessibility. This integration enhances the penetration and outreach of healthcare services, capitalizing on digital tools and extensive datasets to yield valuable insights into well-being. By intertwining healthcare technologies with everyday life, individuals experience continuous health monitoring, leading to a proactive and informed approach to managing their health. Conversely, "persistence" underscores the imperative of sustained and ongoing healthcare intervention and monitoring, empowering individuals to perpetually maintain and enhance their health. Harmonizing "pervasiveness" and "persistence", the P4 evolves into a P6 model and achieves a dynamic framework that, encapsulating predictive, preventive, personalized, and participatory facets, ensures seamless integration into daily life with an unwavering focus on long-term well-being.

Key Enabling Technologies of Health 4.0: A Symphony of Innovations

Achieving Health 4.0, the next stage in healthcare transformation, requires the seamless integration of a range of cutting-edge technologies, working in concert to revolutionize healthcare delivery. These technologies form a technological symphony, where different components work in harmony to enhance healthcare delivery.

At the heart of this transformation lies Artificial Intelligence (AI), a linchpin that revolutionizes diagnostics

with unparalleled accuracy. AI not only refines treatment plans based on individual patient profiles but also acts as a hinge in the assimilation and interpretation of vast health datasets. This, in turn, lays the groundwork for personalized and targeted healthcare interventions.

Complementing AI, Digital Twins leverage the Internet of Things (IoT), seamlessly weaving healthcare into a network of interconnected devices, creating a dynamic ecosystem. Medical IoT sensors and wearable devices collect a wealth of health data in real-time. This massive dataset, enriched with insights from AI, forms the backbone of informed decision-making, allowing for proactive healthcare management and early intervention [8].

The significance of big data analytics takes centre stage in Health 4.0, transforming healthcare into an information-driven domain. Analysing patterns, predicting outcomes, and refining treatment strategies become more than theoretical possibilities – they become practical tools for both individual patient care and broader population health management. Big data analytics becomes the compass guiding healthcare professionals toward evidence-based practices and more efficient resource allocation.

Finally, robotics emerges as a cornerstone, fundamentally altering the landscape of healthcare procedures. From surgical precision to personalized rehabilitation and everyday patient care, robotics introduces a paradigm shift. Its influence extends beyond the operating room, enhancing the quality and efficiency of healthcare services, and promising a future where precision and automation coalesce for optimal patient outcomes.

From the writer's perspective, achieving Health 4.0 extends beyond the mere convergence of technologies; it involves the orchestration of Digital Twins, empowered by Medical IoT sensors and wearable devices, to collect comprehensive health data. This wealth of information is then harnessed by Large Language Models (LLMs) capable of sophisticated analysis and integration, creating meaningful insights. Finally, these insights are fed into AI-powered Personal Telehealth Assistants (PTA). These PTAs, equipped with the ability to communicate with various stakeholders – patients, healthcare workers, and service providers like the National Health Service – bridge the gap between technology and human touch, ensuring a more connected, responsive, and personalized healthcare delivery.

The amalgamation of these technologies encapsulates the essence of Health 4.0 – a transformative journey toward a holistic, data-driven, and interconnected healthcare ecosystem.

3. Applications of Health 4.0 in Society 5.0: Shaping a Proactive and Personalized Future

As Society 5.0 envisions a seamlessly integrated technology fabric, Health 4.0 emerges as a transformative force, reshaping healthcare delivery and steering us towards a healthier and more interconnected society. The convergence of cutting-edge technologies, such as artificial intelligence, robotics, the Internet of Things, and big data analytics, has transformed healthcare into a proactive approach, enabling early detection, personalized treatment, and continuous monitoring.

Telemedicine, a hallmark of Health 4.0, stands as a tes-

tament to this transformation. It has broadened healthcare access for underserved populations and individuals with limited mobility. Through remote consultations facilitated by video conferencing and 24/7 assistance through PTAs, real-time medical care is now accessible, bridging geographical gaps and ensuring that quality healthcare reaches everyone, regardless of their location. This democratization of healthcare dismantles barriers imposed by distance or physical limitations.

Precision medicine, another cornerstone of Health 4.0, revolutionizes treatment approaches by tailoring interventions based on individual genetic and unique characteristics. Analysing extensive patient data, AI-powered algorithms revolutionize treatment approaches by identifying patterns and predicting disease risks, paving the way for personalized treatment plans that optimize efficacy and minimize side effects. This approach has the potential to revolutionize e.g. cancer treatment, offering targeted therapies tailored to specific genetic mutations, thereby enhancing success rates.

Preventive medicine, an integral part of Health 4.0, emphasizes early detection and lifestyle interventions to mitigate the prevalence of chronic diseases. AI-powered diagnostic tools and wearable devices that monitor vital signs enable early identification of potential health risks, facilitating timely intervention and preventing the progression to more severe conditions. Simultaneously, personalized lifestyle recommendations, guided by genetic and behavioural data, empower individuals to adopt healthier habits, reducing the overall risk of chronic diseases and promoting holistic well-being.

Regenerative medicine, a promising field within Health 4.0, holds the promise of repairing damaged tissues and organs, heralding a new era in healthcare. Stem cell therapies, gene editing techniques, and advanced bioprinting technologies offer the potential to regenerate organs like the heart, liver, and kidneys, as well as repair damaged tissues such as cartilage and bone. This groundbreaking approach offers hope for individuals with chronic conditions and those suffering from debilitating injuries, promising not just treatment but restoration of function and improvement in quality of life.

In summary, Health 4.0 stands as a pivotal enabler of Society 5.0, ushering in a healthcare era where individuals are empowered to take control of their well-being. Telemedicine extends access, precision medicine personalizes treatments, preventive medicine fosters well-being, and regenerative medicine offers the promise of restoring damaged tissues and organs. Together, these advancements weave a future where healthcare is proactive, personalized, and accessible to all, aligning with the vision of Society 5.0 – a more harmonious, sustainable, and interconnected society [9].

4. Challenges and Future Directions

As we venture into the uncharted territories of Health 4.0, navigating the path towards an interconnected and harmonious Society 5.0, it is imperative to recognize the challenges that accompany this technological revolution. While Health 4.0 holds immense promise for transforming healthcare delivery, we must address the inherent challenges that arise from the integration of cutting-edge technologies into the delicate fabric of human health.

At the forefront of these challenges stands the delicate balance between harnessing the power of data and safeguarding individual privacy. Health data, a treasure trove of insights into our well-being, must be protected with the utmost vigilance. Health 4.0 necessitates the establishment of a robust framework of data security protocols, ensuring that this invaluable information remains confidential and protected from unauthorized access, such as the EU General Data Protection Regulation (GDPR) and the recently published AI Act [10].

Ethical considerations loom large, demanding thoughtful consideration as we navigate the transformative landscape of Health 4.0. As we unlock new frontiers in healthcare through AI, robotics, and data analytics, ethical frameworks must evolve in tandem. The responsible use of technology mandates a conscientious approach that prioritizes the well-being of individuals, upholding the values of equity, justice, and human dignity.

To fully realize the transformative potential of Health 4.0, a skilled workforce is essential. The seamless integration of advanced technologies requires professionals equipped with the expertise and knowledge to harness the full potential of AI, Digital Twins, data analytics, and robotics. Investing in continuing education programs becomes a strategic imperative, cultivating a cadre of healthcare professionals capable of taking advantage of the latest technological advances. This investment in human capital ensures that Health 4.0 reaps its transformative potential, delivering high-quality, technology-driven healthcare to individuals across diverse landscapes.

As we peer into the future, the trajectory of Health 4.0 unfolds with promise and potential. Advancements in AI capabilities stand at the forefront, with the prospect of even more sophisticated algorithms that enhance diagnostic accuracy, treatment personalisation, and predictive capabilities. Developments in Medical IoT and wearable devices take a quantum leap, evolving beyond monitoring to active intervention, ushering in an era where personalized health guidance is seamlessly interwoven into daily life. The integration of virtual reality (VR) and augmented reality (AR) promises to inject a new dimension into healthcare delivery, offering immersive experiences for medical training, patient education, and even therapeutic interventions.

In conclusion, as we navigate the challenges and gaze into the future horizons of Health 4.0, its pivotal role in enabling Society 5.0 becomes even more pronounced. By addressing challenges through stringent data security measures, ethical considerations, and continuous training initiatives, we fortify the foundations of this transformative healthcare paradigm. Health 4.0, with its ever-evolving landscape, becomes a beacon of revolution in healthcare delivery, promising a society that is not just smarter but healthier, sustainable, egalitarian and deeply interconnected. In the symphony of societal evolution, Health 4.0 strikes a harmonious chord, contributing to the realisation of a future where well-being is a shared and attainable aspiration for all.

References

1. Fukuyama M. (2018), *Society 5.0: Aiming for a new human-centered society*. «Japan Spotlight», 27(5), pp. 47-50.

2. *Realizing Society 5.0*, available online: https://www.japan.go.jp/abenomics/_userdata/abenomics/pdf/society_5.0.pdf (accessed on 10 December 2023).

3. *Society 5.0. Japanese Council for Science, Technology and Innovation*, available online: https://www8.cao.go.jp/cstp/english/society5_0/index.html (accessed on 15 December 2023).

4. Chen F., Huang J., Wang C., Tang Y., Huang C., Xie D., Wang T., Zha, C. (2021), *Data access control based on blockchain in medical cyber-physical systems*, «Security and Communication Networks», vol. 2021, pp. 1-14. DOI: https://doi.org/10.1155/2021/3395537.

5. Zengin Y., Naktiyok S., Kaygın E., Kavak O., Topçuoğlu E. (2020), *An Investigation upon Industry 4.0 and Society 5.0 within the Context of Sustainable Development Goals*, «Sustainability», 13(5), 2682, DOI: https://doi.org/10.3390/su13052682.

6. Al-Jaroodi J., Mohamed N., Abukhousa E. (2020), *Health 4.0: on the way to realizing the healthcare of the future*. «Ieee Access», vol. 8, pp. 211189-211210.

7. Flores M., Glusman G., Brogaard K., Price N.D., Hood L. (2013), *P4 medicine: how systems medicine will transform the healthcare sector and society*, «Personalized medicine», 10(6), pp. 565-576.

8. Nakashima H., Hayashi K., Gotoh H. (2021), *Data-driven Medical and Health Support Created Using Bio-digital Twin NTT Basic Research Laboratories*, available online: https://www.rd.ntt/e/research/JN202105_13473.html (accessed on 18 December 2023)

9. Ciasullo M.V., Orciuoli F., Douglas A., & Palumbo, R. (2022), *Putting Health 4.0 at the service of Society 5.0: Exploratory insights from a pilot study*, «Socio-Economic Planning Sciences», 80, 101163, DOI: https://doi.org/10.1016/j.seps.2021.101163.

10. Smuha N.A., Ahmed-Rengers E., Harkens A., Li W., MacLaren J., Piselli R., Yeung K. (2021), *How the EU can achieve legally trustworthy AI: a response to the European Commission's proposal for an artificial intelligence act*, available at SSRN 3899991.

Traditional Medicine and Folk Religions in Ethiopia-Wallo

by Mohammed Worku Hailemariam*

Abstract
This article focuses on Folk Islam in Wolo, paying special attention to the people, objects, places, times, and rituals that are seen as sources of healing power in spiritual realm. These different sources of power will be analyzed from the point of view of their religious aspect and also from the point of view and practice of other religions. These power centers are similar in form to other folk religious movements, but they differ in their inner content and doctrine. In our country, Ethiopia, the focus of many people is on form and name rather than content. The manifestation of this is mainly in folk religion and traditional medicine. The issue of practicing and using spiritual power to achieve healing is accepted by many religious groups. However, especially in a few, it appears to be out of balance. Of these, Folk Islam and Folk evangelical movements are mentioned. The research questions of the study are the relationship between spiritual power and traditional medicine in Folk Islam and what the relationship between Folk evangelical believers is. From the point of view of the basic teachings of religions, how far can this practice and activity of traditional religious medicine lead to an unwanted and syncretistic approach? The purpose of this article is to understand these folk Islam traditional medicine activities and to investigate the similar aspects in other religions and customs by raising relevant questions to pave the way for future researchers.

Keywords
Traditional Medicine, Folk Religion, Islam, Muslims, Evangelical, Healing, Yebalye, Believers, Syncretism, Spirits, Zar, Awlliya, Sheikhs, Kalcha, Power People, Power Objects, Beads (Chale), Amulets, Power Places, Grave Sites (Gatā), Power Times, And Power Rituals, Wadaja (Friendship), Abdul Qadir Jilani.

1. Introduction

Ethiopia is located in the Horn of Africa at the East Africa Region with a population size of over 120 million and 88+ people and language groups. Ethiopia is a home for Christians and Muslims for over a thousand of years. Since the 7th Century, Islam has been practised in Ethiopia by millions of people. Currently, about 35% of the total population are Muslims under Sunni Islam, mainly Sufis with Qādiriyya order, 63% Christians with an Orthodox majority, followed by Protestants and with very little percentage of Catholics as well as indigenous traditions. Traditionally, Ethiopia has been considered a Christian island.

* Ethnographic Researcher, Lecturer of Islam, Mission, and Islamic movements, at the Evangelical Theological College and the Ethiopian Graduate School of Theology.

However, this notion has been challenged[1]. The 2007 census shows that Muslims accounted for 33.9 percent, Christians accounted for 62.8 percent (Orthodox 43.5, Protestant 18.6 and Catholic 0.7 percent respectively) and the remaining populations belong to different indigenous traditions.

Ethiopia was the first to host Islam by providing refuge to the migrants who were companions (*ṣaḥāba*) of Prophet Muhammad in the early days of Islam, 615. So, Islam reached the Ethiopian soil prior to many African countries, which could also reinforce the strategic nature of Ethiopia with regard to Islam. However, the majority of muslims is more inclined to Folk Islamic religion and practices with traditional medicines. Moreover, a significant number of evangelical believers (protestants) are practicing similar folk religious practices as medicine which could be considered as traditional medicine. The use of traditional medicine in folk religions is a bit unprofessional and unethical, which fact demands a serious scrutiny in this field of studies.

2. What is Folk religion?

The word Folk refers to the belief and practice of the majority of the population. This practice is famous, popular and hated by formal followers. Many religious people in our world practice their religious commitment based on Folk practices. However, no one would say that what I do is 'Folk' practice. This name 'Folk' originates from scholars in the field. Paul Hebert, Daniel Shaw, and Tite Tienu elaborate on this issue in their book *Understanding Folk Religions*[2]. Scholars have been promoting this division and expression by examining the direct and clear teachings of a religion and doing appropriate research in terms of what is done in practice.

They classify them according to the findings of their research saying that this is a mixture of the actual and the Folk arrangement.

> Usually, those who are vulnerable to this traditional religious treatment are: – Those who want hope, who want help, especially those who want to get out of their situation and problems in a way that is different from the usual practice. The Muslim's Journey to the Supernatural Power is mentioned as follows: – The helpless and hopeless often take action to connect with a supernatural force. This type of event is considered customary among Muslims. (Swartley, 2005, p. 196)[3].

Although Folk Muslims believe in Allah, they are bound to join traditional practices and alien worship. This situation is not only found among Muslims but also among followers of other religions. The main characteristic and manifestation of folk religion is that it strives to satisfy the feelings and needs of the majority of the people. In the book mentioned above, a writer named Rick Love states:

> Their main focus is on the daily problems and life, but they have little understanding of the ultimate goals of life. What will continue to satisfy these people is power and success, not truth, logic, and a sustainable approach. (Love, 2000. p. 209)[4]

Folk Islam in Wallo is seen from the same perspective. People think they believe in an all-powerful creator, but they combine this belief with belief in other powers.

A. Belief in one creator (Allah) and other powers (spirits)

Folk Islam in Wallo is considered by its followers to be the true path of Islam. But when their practice is examined in depth, their traditional behavior weighs it down. In particular, not few people see coexistence with alien spirits and (*zars*) as a suitable way of life. Some call the alien spirit above them: '*yebalye*' in control of me. They think that the life they live is their lot of opportunities given by that spirit. Yet many are not in health, but in sickness; They live in fear, not confidence. Although Folk Muslims say that there is no God other than the Creator, many of them live in fear of evil spirits. We find this issue described by one of the writers in the book, *Encountering the World of Islam*, suggests:

> Although Muslims believe in the greatness of Allah, many of them live in fear of evil spirits. The religion teaches that there is only one God and that there is no other intermediary between man and Him. However, a large number of Muslims are looking for someone with special prophetic powers.[5]

These people think that Allah is far away from them. According to J. Spencer Trimingham, they tend to seek power from a closer source, from spirits and gods. He suggests:

> God's unity must be preserved in any situation. However, due to God's remoteness and fear, the intercessors of spirits are needed. (Trimingham, 1952, p. 256)[6]

Trimingham suggests, *zar* was inherited from mixed powers. Traditional Islam in Wallo is based on the worship of evil spirits and the fear of evil forces. There is no doubt about believing in God's power, but the belief is mixed with other powers.

According to one of my informants, Aregu Ali[7], mentioned about someone who controls her life which most of the people in Wallo have what they call a chief (*yebalye*) or a controller. The meaning of *yebaly*): He who controls me or rules me. It is common to consult a superior when faced with important issues in life. Therefore, the belief of these people in one creator is interwoven and connected with the belief in other spirits and powers. Because of their frequent use of Allah's name and their claim that they have good understanding, the extent of the suffering has been compounded.

B. Believing in people: Shaykhs, Prophets and Awlliya

Folk Islam in Wallo gives great respect to sheikhs, *kalcha* (a kalcha is a good name and feeling positive) to people who are considered holy. These are the people who lead the people into various alien cults and practices. These people are considered to have power (spiritual power). Hence, they become famous and perform famous acts.

These powerful people are thought to be close to the Creator. This is what Folk Islam believes. Healing, blessings, and other good fortunes and opportunities await you in the Wadaja ritual. They spit on people they think are our enemies (even when they aren't). Their touch and what they spit is important and useful, no matter how they do it. Sometimes khat is tasted and chewed and spit on a person's head, face, or where there is pain. Their prayers are considered very important. Also, their touch is considered to be a source of blessings. Their saliva is some-

times considered a powerful channel of spiritual energy.

Haji Sayid Bushra is one such person. His burial place is located on a high and hilly place in Kembolsha Wallo called Gatā. Haji Sayid Bushra died in 1855. However, people still consider them as saints and intercessors. Currently, the guardian and main person of that place is Haji Muhdin Adam. He has been serving there for more than three decades. People believe in this person and when they visit him, they bring him gifts.

One of my informants, Aregu, said: "Slaughtering an animal (*madmat)* is allowed only for a sheikh or a *kalcha*. Anyone who does not have this title cannot slaughter; especially the slaughter for sacrifice" (Argue Ali interview, 4 February 2002).

C. Belief in various alien or inanimate objects: sand, amulets and holy water

Beads (*chale*): is used as a tool for intercessory prayer while invoking spirits, saints and Awlliyas. For example, Abdul Qadir Jilani and Sheikh Nur Hussain are prominent figures in Wallo Folk Islam. Chale is used by many followers of traditional Islam in prayer at the end of the year (Pagumen season, 13th Months' of Ethiopian Calendar). Women usually wear it around their necks. This is done after immersing in butter. If there is a different order, men do it too; but without this, they don't. In this way, they thank God for the past year. They ask God for his blessing of the coming year.

Amulets: this is words or texts written on it and hung around people's necks or tied to their arms. The writings include verses from the Qur'an and the names of Allah. The first chapter of the Qur'an is Surah al-Fatiha (the opening chapter). People who make or hang this amulet think and believe that they will be protected from evil and will have success in business, farming, and their future life plans.

Another thing is *holy water*, which is called *Zamzam water* and is a prayer found in every area. Zebanai Tilahun[8], one of my informants, who also practices witchcraft (she is called expert): she believes in the holy water at Jama Oda in her area. This place is located in Woreilu Jama in Deglo town. This holy water is believed to cure any illness. The special respect given to Zamzam water coming from Mecca has always been preserved. Zamzam water is one of the things that many Muslims bring back after performing the Hajj in Mecca.

Folk Islam is very much concerned with belief in different objects; One of the possible reasons for this is Arabia's pre-Islamic conditions and practices. This practice has been easily transferred to today's religious practices. If a person falls ill, following the procedure, taking a verse from the Quran and writing it in ink, dissolve it in water and put it in a glass so that the sick person can drink it. The traditional practice easily leads to a belief in the object and the physical items. The purpose of believing in these objects stems from seeking protection, blessing and healing.

One of my informants, in Woreilu-Jama, said: "Zamzam water is a very useful medicine. A person who drinks this water will be fat, his beauty will be restored, he will be beautiful" (Sheikh Muhammad Juhar interview: 2 February 2002).

Saeed Ibn Ali wrote about Zamzam water in his small book:

> Allah's Messenger Zamzam said about water: – It is

> blessed. It is food for the hungry and medicine for the sick. Said /Muslim/. (1991, p. 89)

> As reported by Jobir, the Messenger of Allah said: – Zamzam water is used for the purpose of drinking. He said. /Ibn Majah/. (1991, p. 90)

Ibn al-Qayyim wrote: "I and the others tried treating him with Zamzam water. We have had excellent results. I have used it as medicine for many diseases and have been cured by Allah's will" (1991, p. 90).

Rick Love, summarizes and suggests: looks at the objects of magic and magic based on his informants; these are:

> The analysis of one of my informants was very thoughtful. He counted seven different types of spells for me: 1) Weapons 2) Verses 3) Objects buried in the body 4) Rings 5) Gifts and ornaments from family 6) Various objects taken from holy places such as soil taken from graves and so on 7) Any inanimate object. Energize by people with different high powers. (Love, 2000, p. 31)

D. Believing in special places, grave sites and the like: – Gatā

Graveyards and houses have a special significance in the life of most (ordinary people) in Wallo Folk Islam. There are many cemeteries and houses in South Wallo connected with Qadriyya Sufi orders. Of these, Jama Nigus and Gatā are the main references. Jama Nigus was founded by Sheikh Muhammad Shafi bin Asqari Muhammad in the 18th Century. According to Hussein Ahmed, Sheikh Muhammad played an important role in the development of Sufi order.

They had a fundamental role in spreading the Qadriyya system. This is the second important aspect of transmission of the system which was initiated by the Yaju scholar, Faqih Zubair. He in turn taught his eldest son and many others about the Sufi order (Ahmed 2001. p. 83)[9].

One of Hussain Ahmad's informants, Sheikh Muhammad Jama, described Sheikh Muhammad Shafi as: Zakir, teacher, mujahid (fighter/advocate in religious affairs) and a sheikh of the Sufi order. After his death in 1806/7, the place where he worked and the place where he was buried turned into a Sufi teaching institution and a holy and special place. When pilgrims arrive at that place, the first thing they do is bow down and draw a picture of the tomb in front of them. This practice is similar to the practice of Ethiopian Orthodox Tewahido Church people.

As Hussain Ahmed suggests: "This behavior shows a very intimate and emotional situation. This reveals the inner feeling that makes people intercede for blessings and intercession. Those who suffer from mental illness, are possessed by evil spirits, and suffer from violent passions, scream, fall, and faint under the influence of powerful spirits. These people are put on their feet by the hosts there or by the people who come with them. This peculiar spectacle and behavior is transferred to the process of exorcism. And the evil spirit that was troubling the person will be driven away by the invisible spirit of the Holy One. That is, falling unconscious is considered to be a struggle when the evil spirit is released" (Ahmed 2001, p. 85)[10]. After this, the pilgrims visit the house of the main and honorable person in that holy place and give gifts and kiss his right hand (this is done be-

cause it is considered to be the transmission of the blessing of the saint).

The holy place at Gatā was founded by the respected and learned mystic and reformer Al Haji Bushra Aya Muhammad. From the middle of the 18th Century, the place called Gatā was a major teaching center of the Sufi order. Al Hajj Bushra is considered as the Wali and the main cause of Karma. In common sayings (legend) it was said: Bushra found the breath of Sayyidina Kader in their mouths. Following this, Bushra's body grew to an unimaginable size.

According to Hussain Ahmed's explanation from his informants, there is a prophetic announcement from an unseen voice (Hatif) about Syed Bushra: He who sees Bushra will have a happy relationship; It is said that the fire of hell will not touch him.

Through these saints, people show a special respect for the places. Thousands of people gather every year on the eve of Mawlid. After doing this, when they return to their respective areas, they take soil and other things from there and use it as medicine and to protect themselves.

E. Belief in various rituals: friendship and prayer

Trimingham defines Wadaja as: A major religious ritual... a family or community prayer meeting... The word Wadaja is used in Wallo... for the Islamic night (*Adar*) prayer. But the word is also used for a meeting associated with sorcery and sorcery (1952, p. 262)[11].

Berhanu Gebeyehu, in his study of Islamic Oral Literature, uses the local poetry and puts the purpose of Wadaja as follows:

> I am not afraid when they say there is a problem.
> I am not afraid of being sick when they say I am sick. I am not afraid when they say there is a problem.
> So long as I have my brothers for these problems.
> I will release by calling them. (Berhanu 1998, p. 39)[12]

Kelkilachew Ali argued that the word "Wadaja" may have come from the word "friend". This is equivalent to the Amharic word *wadaj/gwadegna. Ma-wadaja* conveys the meaning of creating friendship between man and man and between God and man. This is the religious and social aspect of the ceremony.

The Wadaja ceremony is usually performed during the month of Pagumen (the 13th months of Ethiopian). The purpose of this is to thank for the past year and pray for the coming year. According Gebeyehu[14], he revealed: Friend is a regular group meeting. It includes Muslims and Christians. Kchat, incense, lamb or chicken or porridge are offered on friends. The consecration and blessing will follow.

F. Believing in days and seasons: Wednesday is different for Abdul Qadir Jilani

In Wallo traditional Islam, the days of the week are dedicated to the saints. For example: Nurhusen on Tuesday, Abdul Qadir Jilani on Wednesday, Seyedina Kedir on Saturday. This type of practice is common in other areas of Ethiopia. Prayer on these special days is considered powerful and effective. Abdul Qadir Jilani also has many good names: Inspirer of Faith, Beloved by Allah, Chief Guardian. They are very loved and respected by Wallo. In some legends and traditional sayings: As I got from my informant Hajer Kahesay:

> Every Wednesday Jilani rose from his burial place in Baghdad, wearing white wings and sitting on a white horse. He comes to Wallo, wearing white riding gear with white beards, then he visit his farms there and then he visit those who are ready to meet him. (Interview 20 March 2007)

3. Survey of traditional Islam and traditional evangelical believers

See Tables 1, 2, 3, 4 and 5.

4. Conclusion

All sort of movements of folk religions with regard to traditional medicines are exposed for unprofessional, and unethical practices which could be hindrances for the development of scientific medicines. Such movements and practices which influence millions of people in a country like Ethiopia need further exploration and scrutiny by the researchers in the field of sociology of religion as well as medics.

Tab. 1. A. People with spiritual power.

A. People with spiritual power	
Folk Muslims	**Folk evangelical believer**
Haji, Sheikh, Kalicha.	Apostle, Prophet, Pastor, Elder, Evangelist.
Elderly people and youth.	Elderly people and youth.
Those who have received formal theological education and those who have not received formal theological education.	Those who have received formal theological education and those who have not received formal theological education.

Tab. 2. B. Various foreign and inanimate objects.

B. Various foreign and inanimate objects	
Folk Muslims	**Folk evangelical believers**
Zamzem water and local holy water.	Ordinary water and oil.
Quran.	Bible.
Use dirt and anything from the grave area.	As a guide from the spirit.
Chale, amulet.	Handkerchief.

Tab. 3. C. Sacred places/area.

C. Sacred places/ areas	
Folk Muslims	**Folk evangelical believers**
Cemeteries.	Chapels/Prayer rooms, Office of the Apostle.
Graveyards.	Pulpits of the churches.
Mosque premises.	Church/prayer house premises.

Tab. 4. D. Special seasons/days.

D. Special seasons/days	
Folk Muslims	**Folk evangelical believers**
Wednesday, Friday and the eve of Mawlid.	S Friday, Saturday, and Sunday.
Pagumen (the Ethiopian 13th Month's) Wadaja.	Pagumen 5 or 6 days of fasting and prayer at the end of the year.
Various Wadaja Rituals	Whole Night prayers.

Tab. 5. E. Various procedures.

E. Various procedures	
Folk Muslims	**Folk evangelical believers**
Zyera, Zar's movements	Emotional and devotional chants
Various Wadaja rituals	Praying holding hands and hand-in-hand
Cursing enemies	Cursing enemies

Notes and General References

1. Ahmed H. (2006), *Coexistence and/or Confrontation: Towards a Reappraisal of Christian-Muslim Encounter in Contemporary Ethiopia*, «Journal of Religion in Africa», 36,(1), p. 10. He noted: "The demonstrators called for the separation of religion from politics, publicly denounced the notion that Ethiopia was an island of Christianity surrounded by Islam, and declared that it was the home of the adherents of other faiths, including Islam. They submitted a petition to the currently formed government".

2. Hiebert P.G., Shaw R.D., Tiénou T., *Understanding Folk Religion: A Christian Response to Popular Beliefs and Practices*, Baker, Grand Rapids 1999.

3. Swartley K.E. (ed.), *Encountering the World of Islam*,- Authentic Media, Tyrone (GA) 2005.

4. Love R., *Muslims, Magic And The Kingdom of God*, William Carey Library, Pasadena, California 2000.

5. Swartley K.E. (ed.), *Encountering the World of Islam*, cit., p. 196.

6. Trimingham J.S., *Islam In Ethiopia*, Oxford University Press, London 1952.

7. Aregu A., *Interview by author*, 4 February 2002, Written notes, Jama, Wallo, Ethiopia.

8. Zebenay T. (Witchcraft), *Interview by author*, 5 February 2002, Written notes, Degelo, Jama, Wallo, Ethiopia.

9. Ahmed H., *Islam in Nineteenth-Century Wallo. Ethiopia: Revival, Reform, Reaction*, Brill, Leiden 2001.

10. Ahmed H., *Islam in Nineteenth-Century Wallo. Ethiopia: Revival, Reform, Reaction*, cit.

11. Trimingham J.S., *Islam In Ethiopia*, cit.

12. Berhanu G., *Islamic Oral Poetry in Wallo: A Preliminary Descriptive Analysis*, MA Thesis, Addis Ababa University School of Graduate Studies, 1998.

13. Kelkilachew A., *Religion, Rituals and Mutual Tolerances in Wallo: The Case of Cabe*, MA Thesis, Addis Ababa University School of Graduate Studies, 1997.

14. Berhanu G., *Islamic Oral Poetry in Wallo: A Preliminary Descriptive Analysis*, cit.

General References

Abd al-Masih (1996), *The Main Challenges for Committed Christians in Serving Muslims,* Light of Life, Villach, Austria.

Ahmed H. (2001), *Islam in Nineteenth-Century Wallo, Ethiopia: Revival, Reform, Reaction,* Brill, Leiden.

Ahmed H. (2006), *Coexistence and/or Confrontation: Towards a Reappraisal of Christian-Muslim Encounter in Contemporary Ethiopia*, «Journal of Religion in Africa», 36(1).

'Ali A.Y. (1999), *The Meaning of The Holy Qur'an: New Edition with Revised Translation, Commentary and Newly Compiled Comprehensive Index,* Amana Publications, Beltsville, Maryland.

Ali M.M. (1978), *A Manual of Hadith,* Curzon Press, London, 3rd ed.

Berhanu G. (1998), *Islamic Oral Poetry in Wallo: A Preliminary Descriptive Analysis,* MA Thesis, Addis Ababa University School of Graduate Studies.

Bradshaw B. (1993), *Bridging the Gap: Evangelism, Development and Shalom,* MARC, London.

Burgess S.M., McGee G.B., Alexander P.H. (Eds) (1988), *Dictionary of Pentecostal and Charismatic Movements,* Zondervan Publishing House, Grand Rapids.

Central Statistical Agency, Federal Democratic Republic of Ethiopia (2007), *Statistical Abstract,* Central Statistical Agency, Addis Ababa.

Central Statistical Authority, Federal Democratic Republic of Ethiopia Office of Population and Housing Census Commission (1999), *The 1994 Population and Housing Census of Ethiopia: Results at Country Level Volume II Analytical Report,* Central Statistical Authority, Addis Ababa.

Cragg K. (1975), *The House of Islam;* The Religious Life of Man Series, Dickenson Publishing Company, Encino, California.

Cragg K. (1976), *The Wisdom of the Sufis,* Sheldon Press, London.

David Ministries Foundation (2002), *The Complete Christian Dictionary: For Home, School and Office,* Oasis International Ltd, Geneva, IL.

Demissew K. (2006), *Works That Save: The necessity of Works for the Salivation of One Who is saved by Faith alone. Jacobite Soteriology and its Relevance for Orthodox and Evangelicals Soteriology in Ethiopia*, MTh Thesis, Ethiopian Graduate School of Theology, Addis Ababa.

Eric W. (1998), *Equipping Christians Towards An Effective Witness To Their Muslim Friends And Neighbours: A Strategy for Eastern Africa, A Ministry Perspective Project*, MA Thesis, Columbia International University, Columbia, South Carolina.

Esack F. (2002), *The Qur'an: A Short Introduction,* One world Publications, Oxford.

Esposito J.L. (1988), *Islam The Straight Path,* Oxford University Press, Oxford.

Gehman R.J. (1989), *African Traditional Religion: In Biblical Perspective,* Kesho Publication, Kijabe, Kenya.

Gibb H.A.R., Kramers J.H. (2001), *Concise Encyclopaedia of Islam,* Brill, Leiden.

Gibb H.A.R., Kramers J.H. (1991), *Shorter Encyclopaedia of Islam: Fourth Impression,* Brill, Leiden.

Gilchrist J. (1994), *The Qur'ān: The Scripture of Islam*, Life Challenge Africa, Claremont, South Africa.

Goldsmith M. (1982), *Islam and Christian Witness*, Inter Varsity, Downers Grove, Illinois.

Grudem W. (1994), *Systematic Theology: An Introduction to Biblical Doctrine*, Inter-Varsity Press, Leicester, England.

Hiebert P.G., Shaw R.D., Tiénou T. (1999), *Understanding Folk Religion: A Christian Response to Popular Beliefs and Practices,* Baker, Grand Rapids.

Hughes T.P. (1994), *Dictionary of Islam: Being A Cyclopaedia of The Doctrines, Rites, Ceremonies, And Customs, Together With The Technical And Theological Terms of The Muslim Religion*, Kazi Publication, Chicago, IL.

Idris G.S. (1977), *The Pillars of Faith*, Islamic Teaching Centre, Indianapolis, Indiana.

Jeffery A. (1958), *Islam, Muḥammad And His Religion: The Library of Religion A Series of Readings in the Sacred Scriptures and Basic Writings of the World's Religions, past and present, Number Six*, The Liberal Arts Press, New York.

Jomier J. (1989), *How to Understand Islam,* translated by John Bowden, SCM Press, London.

Kateregga B.D., Shenk D.W. (1997), *A Muslim and A Christian in Dialogue*, Herald Press, Scottdale, PA.

Kelkilachew A. (1997), *Religion, Rituals and Mutual Tolerances in Wallo: The Case of Cabe*, MA Thesis, Addis Ababa University School of Graduate Studies.

Love R. (2000), *Muslims, Magic And The Kingdom of God*, William Carey Library, Pasadena, California.

Mbiti J.S. (1969), *African Religions and Philosophy*, East African Educational Publishers Ltd., Nairobi.

Miller W. McElwee (1969), *Ten Muslims Meet Christ*, Eerdmans, Grand Rapids.

Musk B.A. (1995), *Touching the Soul of Islam: Sharing the Gospel in Muslim Cultures*, MARC, London.

Musk B.A. (2003), *The Unseen Face of Islam: Sharing the Gospel with Ordinary Muslims at Street Level*, Monarch, London.

Nazir-Ali M. (1987), *Frontiers in Muslim-Christian Encounter*, Regnum Books, Oxford.

Nehls G., Eric W. (2005), *Islam Basic Aspects: As it sees itself, As others see it, As it is*, Life Challenge Africa, Nairobi.

Parshall P.L. (1980), *New Paths in Muslim Evangelism: Evangelical Approaches to Contextualization*, Baker, Grand Rapids.

Parshall P.L. (1983), *Bridges to Islam: A Christian Perspective on Folk Islam*, Baker, Grand Rapids.

Parshall P.L. (1985), *Beyond the Mosque: Christians within Muslim Community*, Baker, Grand Rapids.

Parshall P.L. (2000), *The Last Great Frontier: Essays on Muslim Evangelism*, Open Doors, Philippines.

Parshall P.L. (2002), *The Cross and The Crescent: Un-*

derstanding the Muslim Heart and Mind, Authentic Media, Waynesboro, GA.

Parshall P.L. (2002), *Understanding Muslim Teachings and Traditions: A Guide for Christian*, Baker, Grand Rapids.

Parshall P., Parshall J. (2002), *Lifting The Veil: The World of Muslim Women*, Authentic Media, Waynesboro, GA.

Rahman F. (1979), *Islam*, University of Chicago Press, Chicago.

Riddell P.G., Cottrell P. (2003), *Islam in Context: Past, Present and Future*, Baker Academic, Grand Rapids.

Sakr A.H. (1997), *Book of Inquiries*, Foundation for Islamic Knowledge, Lombard, IL.

Shenk D.W. (2003), *Journeys of the Muslim Nation and the Christian Church: Exploring the Missions of two Communities*, Herald Press, Scottdale, PA.

Still W. (1974), *Power Encounter: Biblical Teaching on the Devil*, New Life Literature, Sri Lanka.

Swartley K.E. (ed.) (2005), *Encountering the World of Islam*, Authentic Media, Tyrone, GA.

Trimingham J.S. (1952), *Islam In Ethiopia*, Oxford University Press, London.

Trimingham J.S. (1962), *A History of Islam in West Africa*, Oxford University Press, London.

Watt W.M. (1962), *Islamic Philosophy and Theology*, Islamic Surveys, Edinburgh University Press, Edinburgh.

Wehr H. (1994), *Arabic English Dictionary: A Dictionary of Modern Written Arabic*, Spoken Language Services, Ithaca.

Woodberry J.D. (ed.) (1989), *Muslims and Christians on the Emmaus Road*, MARC Publications, West Huntington, CA.

Unpublished Papers and Interviews

Adem Amede, Interview by author, 3 February 2002, Jama, Wallo, Ethiopia, Written notes.

Ahmed Getachew, Interview by author, at Mawlid Celebration, March, 2007, Gatā, Wallo, Ethiopia, Written notes.

Ali Muheye, Interview by author 7 February 2002, Were-Ilu, Wallo, Ethiopia, Written notes.

Aregu Ali, Interview by author, 4 February 2002, Jama, Wallo, Ethiopia, Written notes.

Hajer Kahesay, Interview by author 20 March, 2007, Addis Ababa, Ethiopia, Written notes.

Islam Seminar, Vom, Neckarimern, 22-28 June 2003.

Kebede, Endere, Interview by author, 6 February 2002, Woin-Amba, Wallo, Ethiopia, Written notes.

Mekane Yesus Theological Seminary A Collection of Articles Compiled by, Theology Department, Program in Christian-Muslim Relations, *Islam in Ethiopia: Contemporary Aspects*, 2003.

Mekane Yesus Theological Seminary A Collection of Articles Compiled by, Theology Department, Program in Christian-Muslim Relations, *Islamic Law*, 2004.

Selam, Interview by author 19 March, 2007, Addis Ababa, Ethiopia, Written notes.

Sheikh Ashabir, Mekonene, Interview by author, 6 February 2002, Woin-Amba, Wallo, Ethiopia, Written notes.

Sheikh Muḥammad, Juhar, Interview by author 2 February 2002, Degelo, Jama, Wallo, Ethiopia, Written notes.

Tilahun, Yūsuf, Interview by author, 2 February 2002, Dessie, Wallo, Ethiopia, Written notes.

Yosef, Addisie, Interview by author, 6 February 2002, Were-Ilu, Wallo, Ethiopia, Written notes.

Zebenay, Tilahun, (Witchcraft), Interview by author, 5 February 2002, Degelo, Jama, Wallo, Ethiopia, Written notes.

Audio Recording

Audio Recording of Berren, Herbert, by Author, October 2002, Addis Ababa, Ethiopia.

Audio Recording, by author, February 2002, Jama, Were-Ilu, Wallo, Ethiopia.

Audio Recording, by author, February 2002, Degelo, Jama, Wallo, Ethiopia.

Audio Recording, by author, February 2002, Woin-Amba, Wer-Ilu, Wallo, Ethiopia.

Audio Recording of Mawlid Celebration at the Sanctuary at Gatā, by author, March 2007, Wallo, Ethiopia, Gatā, Wallo, Ethiopia.

Journals, CD Rom and Web Site

Ahsan M. (Ed.) (2002), *The Muslim World, Book Review, Vol. 22 No 4 July-September 2002: Containing an Index of Islamic Literature,* The Islamic Foundation and The International Institute of Islamic Thought, The Muslim World Book Review The Islamic Foundation, Markfield Conference Centre, Ratby Lane, Markield, Leicester LE679SY, UK.

Braukämper U. (1988), *"Islamicization of the Arsi-Oromo" 8th International Conference of Ethiopian Studies,* Frobenius Inst., German, pp. 767-777.

Bushell M.S., Michael D., LLC., *Bible Works 6.0,* USA 1992-2003 [CD ROM].

http://en.Wikipedia.org/wiki/Abdul_Qadir_Jilani,

Rashid, S. (1997), *Hamdard Islamicus*, April-June 2000,

Volume XXIII, 2, Quarterly Journal of Studies and Research in Islam Published by Bait al-Hikmah at Madinat al-Hikmah, Hamdard Foundation, Karchi, Pakistan.

The Islamic Quarterly, Volume XLIV, 2, Second Quarter 1421/2000 The Islamic Cultural Centre, London.

Amharic Books

የሶላት መማሪያ እና አርካኑል ኢስላም አርካኑል ኢማን፤ የነቢዩ አሰጋገድ፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ ድርጅት፤ 1988.

አብዱልመጂድ አዘንዳኒ፤ ከኢማን አድማስ፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሳታሚ ድርጅት፤ 1987.

አቡል አዕላ መውዱዲ፤ ቁራንን ለመረዳት፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሳታሚ ድርጅት፤ 1987.

አደም መሐመድ እና ሐጅ ዐብዱረሕማን ሸሪፍ፤ የፊቅህ መጀመሪያ፡ – ስለእስልምና ሃይማኖት የሚገልጽ መጽሐፍ ክፍል *1*። አዲስ አበባ፤ ብርሃንና ሠላም ማተሚያ ቤት፣ *1*985.

ሐሰን ታጁ፤ ዘካ፡ – ቁራንና ሐዲስን መሠረት ያደረገ የዘካ አወጣጥ ሥርዓት፡፡ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሣታሚ ድርጅት፣ 1991.

ኢማም ነወዊ፤ አርባ ሐዲስ፡ – እንደ ሒጅርያ የዘመን አቆጣጠር በ *676* ባረፉት በኢማም የሕያ ኢብኑ ሸረፈዲን አልነወዊ.

የተሰበሰቡ ሷሒህ ነቢያዊ ሐዲሶች፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሣታሚ ድርጅት፣ 1986.

መሐመድ ጀማል መኽታር፤ እስላም ምንድነው?.

—, ሐጅ አፈጻጸሙና ፍልስፍናው፡፡.

የረመዳን ወር እና የጾም ሥርዓት፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሳታሚ ድርጅት፤. ቅዱስ ቁራን፤ አዲስ አበባ፤ አርቲስቲክ ማተሚያ ሊሚትድ፤ 1961.

ሰዒድ ኢብን ዐሊ ኢብን ወህፍ አል-ቀሕጧኒ፤ ከተለያዩ በሽታዎች ፈውስ እና ዱዓእ፤ ከቁርአንና ከሐዲስ፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሳታሚ ድርጅት፤ 1991.

—, ሒስኑል ሙስሊም፤ ከቁራንና ከሐዲስ የተውጣጡ ውዳሴዎች ፤አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሳታሚ ድርጅት፤ 1991.

—, አስማኡላሂል ሑስና፤ (የአላህ መልካም ስሞች ትንታኔ) ፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ አሳታሚ ድርጅት፤ 1993.

የሶላት መማሪያ እና አርካኑል ኢስላም አርካኑል ኢማን፤ የነቢዩ አሰጋገድ፤ አዲስ አበባ፤ ነጃሺ ኢስላሚክ ድርጅት፤ 1988.

.

Authors

Carlo Capotondi

Graduated in Medicine and Dentistry from the University of Rome La Sapienza, where he specialized in Radiology and Diagnostic Imaging. He then obtained a 2nd level master's degree in Endovascular Techniques from the University of Rome Tor Vergata and a master's degree in Vascular Interventional Neuroradiology from La Sapienza. He was responsible for Reference Site for central-southern Italy in the clinical application of radiofrequency thermoablation in the treatment of primary or secondary hepatic neoplastic lesions using a cold needle device. Member of the Technical Commission for the Development of National Guidelines for the use of Teleradiology (joint SIRM-SNR commission). From 2006 to 2018 he was temporary professor of Radiology at the University of Rome La Sapienza and from 2015 to 2018 temporary professor for the 2nd Level Master in Chronic Pain Therapy at the University of Rome La Sapienza. He was 1st level Medical Director in Interventional Radiology at the Sant'Andrea Hospital and UOS Director of Emergency Radiology at the Sant'Andrea University Polyclinic Company.

Gian Marco Contessa

Senior Research Scientist at the Italian National Institute of Health (ISS), where he conducts research in the field of protection from ionizing and non-ionizing radiation. He is Member of the Collaborative Centre of the World Health Organization (WHO). From 2012 to 2023 he has been a Researcher at the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), where he has also been Radiation Protection Expert for the research centers of Casaccia and Frascati. Since 2020, he is Task leader of the Radiation Protection team of ENEA Sorgentina-RF project for the production of medical radioisotopes by means of fusion neutrons. He has a PhD in Biochemistry and Molecular Biology and he is a Medical Physics Expert. Among others, he worked for ISPESL (now INAIL), ASL Roma "C", the Department of Human Neurosciences of University "Sapienza" and the hospital San Pietro Fatebenefratelli. Currently, he is Member of the Board of Directors of the Interregional Professional Order of Chemists and Physicists (LUAM), of the Italian Association of Radiation Protection (AIRP) and of the Italian Federation for Radiation Research (FIRR), and he is adjunct Professor of applied physics at the Universities "Sapienza" and "Unicamillus" in Rome.

Marco D'Arienzo

Physicist Director at the ASL Roma 6, UOSD Health Physics (Ospedale dei Castelli), with the role of Specialist in Medical Physics for ASL Roma 6 and the role of Radiation Protection Expert for Nuclear Medicine. He also deals with radiation protection at nuclear fusion plants and medical accelerators. In the academic field he regularly carries out teaching activities at the UniCamillus International Medical University of Rome (Degree Courses in Medicine and Surgery, and in Medical Radiology Techniques, Imaging and Radiotherapy); at the School of Specialization in Medical Physics of Tor Vergata; at The School of Specialization in Nuclear Medicine of La Sapienza; for the Master Protection Against CBRNe Events at the Department of Industrial Engineering and the Faculty of Medicine and Surgery of the University of Rome Tor Vergata; for the Master in Physical Agents and Radiation Protection at the same university.

Ahmed Hadj Henni

PhD, specialist in medical physics at the Frederic Joliot Center in Rouen, France. He has been working in radiotherapy for ten years. He obtained his PhD in particle physics in 2007 from the University of Nantes, in collaboration with the Brookhaven National Laboratory in the USA. He then moved into medical physics, validating his Diplôme de Qualification en Physique Radiologique et Médicale (DQPRM) at the Institut Curie in Paris in 2015. He also holds a DU in radiosurgery and intra- and extra-cranial stereotactic treatment from the Pierre et Marie Curie Faculty of Medicine in Paris (2014).

Mario Mattia Lomonaco

Final-year student enrolled in the joint master's degree program in Management at both Bocconi University and ESSEC Business School. He holds a bachelor's degree in Finance from Bocconi University. Previously, he worked as an independent contractor for Ampersand Capital Partners in Singapore, a private equity investor specializing in growth-oriented investments within the healthcare sector. Later, he joined Fibronostics as a business analyst intern. Fibronostics focuses on developing non-invasive diagnostic solutions for metabolic diseases. At present, he is a member of the Innovation and Health Chair at ESSEC Business School.

Oleg Missikoff

PhD in Organization of Business Information Systems at LUISS University, with a dissertation on "Cultural Information Systems", completed during his year abroad in Boston at MIT and Harvard Business School. He obtained a Master in Computational Archaeology at the University of Oxford and a Humanities degree at Sapienza University of Rome. His academic activity concerns teaching, publishing and coordinating international projects on various subjects, including AI applications in different disciplines (e.g. education, healthcare, and multiculturalism). His current research interests concentrate on human-centric digital transformation, fostering innovation across interdisciplinary domains.

Federico Spandonaro

Aggregate Professor at the University of Rome "Tor Vergata", Chair of C.R.E.A. Sanità (Centre for Applied Health Economic Research) Scientific Committee. He currently holds lectures on Health Economics, Health Policies, Health Care Management, Regulatory and Pharmacoeconomic Aspects. Former Member of Scientific Committees supporting the Ministry of Health (Planning Directorate, National Committee for Medical Devices Regulation, National Health Care Monitoring System Committee), the National Agency for Regional Health Services, Lazio Region (Technical-Scientific Committee), Independent Evaluation Body of Hospital and Local Health Authorities, "Antimafia" Parliamentary Committee, advisor of the Ministry of Education, University and Research (MIUR) for Research Projects Assessment. Editor of the Annual report on Health Policies by University of Roma "Tor Vergata" and author of many scientific publications on health policies, economics and management, pharmacoeconomics and HTA.

Gian Stefano Spoto

Born in Bologna, professional journalist since 1983. He wrote for numerous newspapers including «la Repubblica», «Il Resto del Carlino», «Corriere medico». In 1988 he joined the Italian television corporation (Rai) where he was special correspondent, editor-in-chief of Tg2, vice-director Raidue and Rai International, correspondent from Middle East in Jerusalem. He has conducted several programs including *Linea verde* and *Futura City* on new technologies. Author of numerous publications and five books, the last two about the war in Gaza.

Mohammed Worku Hailemariam

Ethnographic Researcher, Lecturer of Islam, Mission, and Islamic movements, at the Evangelical Theological College and the Ethiopian Graduate School of Theology. His area of expertise is focused on Folk religions and Tablīghī Jamā'at, an Islamic Renewal Movement. In 2022 he obtained a PhD from Oxford Centre for Mission Studies in Islamic Studies, and in 2008 a MTh in Systematic Theology from the Ethiopian Graduate School of Theology. He works with theological colleges and mission organizations as regional director for the East and Central Africa Region based in Addis Ababa.

Maria Angela Wangui Maina

Kenyan advocate-in-training with a Bachelor of Laws from Strathmore University. She is a legal intern at Pavia e Ansaldo and the Chief Research Coordinator-Africa at The Thinking Watermill Society. Her main research interest is international development law, particularly the realization of the sustainable development goals. As a young lawyer, she aspires to spark socio-political changes through legal writing, research, and advocacy.

The centers of metropolises give the idea of an always more dynamic and technological future, but the world population is increasing, and migration flows make the management of healthcare, which must remain public and at the service of all, complex. In this context, the contribution of the private sector is important, but it must be thought out, conceived and managed.

euro 15,00
issn: 2785-3713
isbn: 978-88-9295-845-6

www.tabedizioni.it