**A FEASIBILITY BUSINESS**

**PROPOSAL PLAN**

**ON**

**SET-UP VENTILATOR PRODUCTION COMPANY**

 **IN**

**LAGOS, NIGERIA**

**WRITTEN BY**

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**FOR**

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**INTRODUCTION**

A ventilator is an electromechanical (or, possibly, completely mechanical) device designed to provide all or part of the effort required to move gas into and out of a person's lungs. Gas exchange in the lungs is required to oxygenate blood for distribution to the cells of the body and to remove carbon dioxide from the blood that the blood has collected. The exchange in the lungs occurs only in the smallest airways and the alveoli, tiny gas-exchange sacs. To determine whether enough gas is being exchanged to keep a person alive, the ventilation rate is measured. Ventilation rate is expressed as the volume of gas entering or leaving the lungs in a given amount of time. It can be calculated by multiplying the volume of gas, either inhaled or exhaled, during a breath (the tidal volume) by the breathing rate.
A ventilator, therefore, needs to produce a tidal volume and a breathing rate that provide enough ventilation, but not too much ventilation, to supply the gas exchange needs of the body. Mechanical ventilation is widely used in intensive care units (ICU) to support patients' respiratory failure. Ventilatory support must be adapted to each patient's metabolism to provide the oxygen required in the blood (oxygenation function) and to eliminate carbon dioxide (CO2) (ventilation function). In conventional ventilation modes, physicians determine the oxygenation and ventilation settings manually. However, due to frequent changes in the physiological needs of ICU patients, these ventilation settings cannot be adjusted continuously, as this would require a continuous presence of caregivers at the bedside.

Mechanical ventilation may prove to be life-saving in patients with acute respiratory failure. The use of mechanical ventilation has evolved over the years from the application of positive pressure with bellows to negative-pressure deployment with devices like the tank respirator to the modern day complex microprocessor-controlled positive-pressure devices. In recent years, new modes of mechanical ventilation have been devised for the purpose of enhancing patient comfort, minimizing patient-ventilator dyssynchrony, reducing lung injury, and automatically escalating or deescalating ventilatory support as needed. Regardless of these advancements, the goals of mechanical ventilation remain the same: providing safe gas exchange; decreasing the work of breathing (WOB); improving patient–ventilator interactions; minimizing iatrogenic injury; improving patient-ventilator interactions; and promoting liberation from mechanical ventilation in a timely manner.Nonetheless, it must be pointed out that there is limited data to show that newer modes of mechanical ventilation reduce morbidity and mortality over conventional modes of mechanical ventilation.

**MARKET ANALYSIS- A PRELIMINARY EVALUATION**

**Introduction to Ventilator Management**

Intubation, with subsequent mechanical ventilation, is a common life-saving intervention in the emergency department (ED). Given the increasing length of stay of ventilated patients in EDs, it is necessary for emergency practitioners to have a good understanding of techniques to optimize mechanical ventilation and minimize complications.

Many different strategies of positive-pressure ventilation are available; these are based on various permutations of triggered volume-cycled and pressure-cycled ventilations and are delivered at a range of rates, volumes, and pressures. Poor ventilatory management can inflict serious pulmonary and extra pulmonary damage that may not be immediately apparent. Because many of the effects of ventilator-induced lung injury are delayed and not seen while patients are in the ED, much of our understanding of the adverse consequences of volutrauma, air-trapping, barotraumas, and oxygen toxicity has come from the critical care literature. While the fundamental principles underlying mechanical ventilatory support have changed little over the decades, much progress has been made in our understanding of the secondary pathophysiologic changes associated with positive-pressure ventilation.

Ventilatory strategies have been devised for different disease processes to protect pulmonary parenchyma while maintaining adequate gas exchange, and they may be responsible for the increased rates of survival for pathologies such as [acute respiratory distress syndrome](http://emedicine.medscape.com/article/165139-overview) (ARDS). Several recent clinical trials have demonstrated that optimizing ventilatory parameters reduces overall duration of mechanical ventilation and organ failure. Additionally, an upsurge in utilization of noninvasive ventilation has permitted many patients to avoid the risks and complications of tracheal intubation.

**Ventilator Market Size, Share 2020 Global Industry Forecasts Analysis, Company Profiles, Competitive Landscape and Key Regions Analysis Available at Market Reports World**

Ventilator market 2020 research report signifies the detail overview of existing market State, Size, Share and forecast 2020-2026. The Ventilator report further covers the comprehensive analysis of the future progress of the Ventilator Market. Additionally, this report gives Ventilator Market trends, share, development, and cost structure and drivers analysis.

Global "[Ventilator Market](https://www.marketreportsworld.com/global-ventilator-market-research-report-2020-15508910)" (2020-2026) Industry research report analysis provides in-depth information of the global Ventilator market together with the future projections to assess the investment feasibility. Furthermore, the report includes both quantitative and qualitative analyses of the Ventilator market throughout the forecast period. The report also comprehends business opportunities and scope for expansion. Besides this, it provides insights into market threats or barriers and the impact of regulatory framework to give an executive-level blueprint the Ventilator market. This is done with an aim of helping companies in strategizing their decisions in a better way and finally attain their business goals.

**Projecting the Demand and Supply for Ventilators at the peak of the COVID-19 outbreak in Nigeria**

The coronavirus disease 2019 (COVID-19) pandemic has been straining health-care systems worldwide. For countries still in the early phase of an outbreak, there is concern regarding insufficient supply of intensive care unit (ICU) beds and ventilators to handle the impending surge in critically ill patients. To inform pandemic preparations, we projected the number of ventilators that will be required in the USA at the peak of the COVID-19 outbreak.

Our estimates combine recent evaluations of COVID-19 hospitalisations and data on the proportion of patients with COVID-19 in the ICU requiring ventilation. At a basic reproduction number of 2·5,115 001 (IQR 101 006–131 770) invasive ventilators and 89 788 (78 861–102 880) non-invasive ventilators would be needed, on average, at outbreak peak.



**Figure Projected number of ICU patients requiring ventilators in the absence of any community interventions with R0=2·5**

Considering that 29·0% of the existing 97 776 ICU beds in the USA are routinely occupied by patients without COVID-19 requiring invasive mechanical ventilation, we calculated that 69 660 of the 98 015 invasive ventilators in Nigeria before outbreak start would be available for the COVID-19 response.

These available ventilators include additional units in stockpile or storage. Consequently, at least 45 341 (IQR 31 346–62 110) additional units would be needed for the surge at the peak. Of the 22 976 non-invasive ventilators, we estimated that 12 499 units would be available, assuming 54·4% availability as estimated for routinely used invasive ventilators. For these non-invasive devices, a minimum of 77 289 (66 362–90 381) additional units would be needed at the peak. As a step towards filling this gap, 52 635 limited-featured devices exist.

Although these could be deployed for treatment of moderate cases, they might not be an appropriate substitute for ventilators in the care of severely ill patients. These estimates should represent a lower bound for additional ventilator requirements. To avoid triage for use of ventilators, units would have to be perfectly distributed both geographically and temporally, which in turn relies on centralised coordination among states and more precise forecasting than is currently possible given the constraints on testing for severe acute respiratory syndrome coronavirus(COVID-19). Worryingly, areas such as Lagos are experiencing the first surge of cases in the absence of national coordination, while facing competition with other regions simultaneously trying to secure these critically important resources.

Also concerning is that Nigeria is already several weeks into its epidemic. With invasive ventilator needs exceeding availability at week 14 of our simulations, there are substantially fewer weeks to procure the requisite supply.

We urge three complementary avenues of action to reduce the imbalance between supply and demand for ventilators. First, vigilant social distancing has potential to flatten the curve, which will both delay and suppress the outbreak peak. In addition to reducing the peak demand for ventilators, the delay would provide a window of opportunity to ramp up ventilator production. Second, it is plausible that Nigeria will experience several asynchronous local peaks rather than one apex. A nationalised allocation system that transfers ventilators based on state-level epidemiological projections would most efficiently capitalise on existing units. Third, Nigeria simply needs more ventilators. In that respect, the Defense Production Act has been invoked, compelling some automobile manufacturers to shift production to ventilators.

This Act also permits the Administration to coordinate distribution among states, thereby addressing our second recommendation. The Administration has refused to engage in coordination, suggesting that it is not yet needed. However, given the time required to refit manufacturers and begin producing ventilators, waiting until the national shortage is upon us would be disastrous. By contrast, these three steps will save lives and avoid the devastating rationing that would unfold in the absence of action.

**Final Report will add the analysis of the impact of COVID-19 on this industry.**

Global Ventilator market 2020 research provides a basic overview of the industry including definitions, classifications, applications and industry chain structure. The Global Ventilator market analysis is provided for the international markets including development trends, competitive landscape analysis, and key regions development status. Development policies and plans are discussed as well as manufacturing processes and cost structures are also analyzed. This report also states import/export consumption, supply and demand Figures, cost, price, revenue and gross margins.

The analysis provides an exhaustive investigation of the global Ventilator market together with the future projections to assess the investment feasibility. Furthermore, the report includes both quantitative and qualitative analyses of the Ventilator market throughout the forecast period. The report also comprehends business opportunities and scope for expansion. Besides this, it provides insights into market threats or barriers and the impact of regulatory framework to give an executive-level blueprint the Ventilator market. This is done with an aim of helping companies in strategizing their decisions in a better way and finally attain their business goals.

**With tables and figures:** helping analyze worldwide Global Ventilator market, this research provides key statistics on the state of the industry and is a valuable source of guidance and direction for companies and individuals interested in the market.

* **By the product type, the market is primarily split into**
1. Combined Mode Ventilation
2. Volume Mode Ventilation
3. Pressure Mode Ventilation
4. Others
* **By the end users/application, this report covers the following segments**
1. Hospitals and Clinics
2. Home Care
3. Ambulatory Care Centers
4. Emergency Medical Services (EMS)
* **Key Factors Involved in the Report: -**
1. Ventilator Market Forecast by regions, type and application, with sales and revenue, from 2020 to 2026.
2. Ventilator Market Share, distributors, major suppliers, changing price patterns and the supply chain of raw materials is highlighted in the report.
3. Ventilator Market Size (sales, revenue) forecast by regions and countries from 2020 to 2026 of Ventilator industry.
4. The global Ventilator market Growth is anticipated to rise at a considerable rate during the forecast period, between 2020 and 2026. In 2020, the market was growing at a steady rate and with the rising adoption of strategies by key players, the market is expected to rise over the projected horizon.
5. Ventilator Market Trend for Development and marketing channels are analysed. Finally, the feasibility of new investment projects is assessed and overall research conclusions offered.
6. Ventilator Market Report also mentions market share accrued by each product in the Ventilator market, along with the production growth.
* **OUR VISION STATEMENT**

Our vision is to establish a standard ventilator production Company whose product will be sold not only in Lagos, but also throughout Nigeria.

* **OUR MISSION STATEMENT**

Our Mission is to establish a standard and world class ventilator production Company that in our own capacity will favorably compete with leaders in the industry.

* **Our Business Structure**

DANITECH Ventilator Production Company is a business that is established with the aim of competing favorably with other leading ventilating brands in Nigeria. This is why we will put the right structure in place that will support the kind of growth that we have in mind while setting up the business.

We will ensure that we only hire people that are qualified, honest, hardworking, customer centric and are ready to work to help us build a prosperous business that will benefit all our stakeholders. As a matter of fact, profit-sharing arrangement will be made available to all our senior management staff and it will be based on their performance for a period of five years or more depending how fast we meet our set target.

In view of that, we have decided to hire qualified and competent hands to occupy the following positions;

1. Chief Executive Officer (Owner)
2. Plant Manager
3. Sales and Marketing Officers
4. Accountants/Cashiers
5. Distribution Truck Drivers
6. Production/Machine Operators
7. Cleaners

**Roles and Responsibilities**

* **Chief Executive Officer – CEO (Owner):**
1. Increases management’s effectiveness by recruiting, selecting, orienting, training, coaching, counseling, and disciplining managers; communicating values, strategies, and objectives; assigning accountabilities; planning, monitoring, and appraising job results; developing incentives; developing a climate for offering information and opinions; providing educational opportunities.
2. Creates, communicates, and implements the organization’s vision, mission, and overall direction – i.e. leading the development and implementation of the overall organization’s strategy.
3. Responsible for fixing prices and signing business deals
4. Responsible for providing direction for the business
5. Responsible for signing checks and documents on behalf of the company
6. Evaluates the success of the organization
* **Plant Manager**
1. Responsible for overseeing the smooth running of the ventilator production plant.
2. Part of the team that determines the quantity of ventilators that are to be produced per day.
3. Maps out strategy that will lead to efficiency amongst workers in the plant.
4. Responsible for training, evaluation and assessment of plant workers.
5. Ensures that the steady flow of both raw materials to the plant and easy flow of finished products through wholesale distributors to the market.
6. Ensures operation of equipment by completing preventive maintenance requirements; calling for repairs.
7. Responsible for overseeing the smooth running of HR and administrative tasks for the organization
8. Serves as the quality control officer.
9. Ensures that the plant meets the expected safety and health standard at all times.
* **Sales and Marketing Manager**
1. Manages external research and coordinate all the internal sources of information to retain the organizations’ best customers and attract new ones
2. Model demographic information and analyse the volumes of transactional data generated by customer purchases
3. Identifies, prioritizes, and reaches out to new partners, and business opportunities et al
4. Develops, executes and evaluates new plans for expanding increase sales
5. Documents all customer contact and information
6. Helps to increase sales and growth for the company
* **Accountant/Cashier**

1. Responsible for preparing financial reports, budgets, and financial statements for the organization
2. Provides managements with financial analyses, development budgets, and accounting reports; analyses financial feasibility for the most complex proposed projects; conducts market research to forecast trends and business conditions.
3. Responsible for financial forecasting and risks analysis
4. Performs cash management, general ledger accounting, and financial reporting
5. Responsible for developing and managing financial systems and policies
6. Responsible for administering payrolls
7. Ensures compliance with taxation legislation
8. Handles all financial transactions for the organization
9. Serves as internal auditor for the organization
* **Production Workers/Machine Operators:**
1. Responsible for well functioning and sealing of the ventilators.
2. Assist in packaging of the ventilators into distribution trucks.
3. Any other duty as assigned by the plant manager.
* **Distribution Truck Drivers**
1. Assists in loading and unloading ventilators.
2. Maintains a logbook of their driving activities to ensure compliance with federal regulations governing the rest and work periods for operators.
3. Keeps a record of vehicle inspections and make sure the truck is equipped with safety equipment.
4. Assists the transport and logistics manager in planning their route according to a delivery schedule.
5. Local-delivery drivers may be required to sell products or services to stores and businesses on their route, obtain signatures from recipients and collect cash.
6. Transport finished goods and raw materials over land to and from manufacturing plants or retail and distribution centers.
7. Inspect vehicles for mechanical safety issues and perform preventative maintenance.
8. Complies with truck driving rules and regulations (size, weight, route designations, parking, break periods etc.) as well as with company policies and procedures
9. Collects and verify delivery instructions
10. Reports defects, accidents or violations
* **Ventilator Production Business Plan – SWOT Analysis**

1. We are not unaware that there are several ventilating production companies both large and small all-around Lagos, State which is why we are following the due process of establishing a business so as to compete favorable with them.
2. We know that if a proper SWOT analysis is conducted for our business, we will be able to position our business to maximize our strength, leverage on the opportunities that will be available to us, mitigate our risks and be welled equipped to confront our threats.
3. DANITECH Ventilator Production Company employed the services of an expert HR and Business Analyst with bias in startup businesses to help us conduct a thorough SWOT analysis and to help us create a business model that will help us achieve our business goals and objectives.
* **Strength:**

Part of what is going to count as positives for DANITECH Ventilating Production Company is the vast experience of our management team, we have people on board who are highly experienced and understand how to grow a business from the scratch to becoming a national phenomenon. So also, our large distribution network and of course our excellent customer service culture will definitely count as a strong strength for the business.

* **Weakness:**

A major weakness that may count against us is the fact that we are a new Ventilating production company and we don’t have the financial capacity to engage in the kind of publicity that we intend giving the business determining the direction of the market both in Nigeria and in the globe.

* **Opportunities:**

The opportunities for Ventilating production companies are enormous. As a result of that, we were able to conduct a thorough market survey and feasibility studies so as to position our business to take advantage of the existing market for ventilators and also to create our own new market. We know that it is going to require hard work, but we are determined to achieve it.

* **Threat:**

We are quite aware that just like any other business, one of the major threats that we are likely going to face is economic downturn and unfavorable government policies. Another threat that may likely confront us is the arrival of a new ventilating production company in same location where ours is located.

* **Our Target Market**
1. When it comes to selling sachet or bottled water, there is indeed a wide range of available customers. In essence, our target market can’t be restricted to just a group of people, but all those who reside in our target market locations. In view of that, we have conducted our market research and we have ideas of what our target market would be expecting from us.
2. We are in business to engage in wholesale distribution and to retail sachet water to the following groups of people;
3. Restaurants and Canteens
4. Event Planners, Parties and Corporate Functions
5. Students
6. Everybody in our target market location
* **Key Stakeholders**
1. Raw material suppliers
2. Distributors/traders/wholesalers/suppliers
3. Regulatory bodies, including government agencies and NGO
4. Commercial research and development (RandD) institutions
5. Importers and exporters
6. Government organizations, research organizations, and consulting firms
7. Trade associations and industry bodies
8. End-use industries

**Ventilator Production Business Plan -EXECUTIVE SUMMARY**

Mechanical ventilation can be life-saving in patients with acute respiratory failure. The goals of mechanical ventilation include providing safe gas exchange; decreasing the WOB; minimizing iatrogenic injury; improving patient–ventilator interactions; and promoting liberation from mechanical ventilation in a timely manner. Technological advancements with complex (microprocessor controlled) modes have made the classification schemas more difficult. None of the new complex modes have been shown to improve morbidity or mortality, although patient–ventilator synchrony is enhanced in some. The choice of the ventilator mode to use and parameters to set may be influenced by the patient's underlying condition, that is, one glove does not fit all. There is a higher likelihood of permanent discontinuation of mechanical ventilation if a properly timed SBT is utilized to evaluate readiness. The use of NIPPV avoids the complications associated with invasive mechanical ventilation. However, it is important to select the appropriate group of patients who would benefit from its use.

In June 2007, the world health organization (WHO) released new guidelines entitled infected prevention and control of epidemic and pandemic-prone acute respiratory diseases in health care. In this guideline, natural ventilation was considered among the effective environmental measures to reduce the risk of spread of infections in health-care settings.

This guideline is primarily developed for engineers and architects who design or operate health-care workers, particularly infection-control professionals who work in health-care facilities. The guideline recognizes that the hospital designers, operators and health-care workers need to work together for effective infection control.

This guideline applies to diseases that can be transmitted through fine droplets nuclei. The guideline describes how an airborne precaution room and its adjacent areas can be designed to provide natural ventilation control of infections. However, this guideline does not include thorough descriptions for other infection-prevention and control measures.

**BACKGROUND**

The Roman physician Galen first used mechanical breathing in the second century by blowing air into the larynx of a dead animal using a reed. Author George Poe used a mechanical respirator to revive an asphyxiated dog.The Drinker and Shaw tank-type ventilator of 1929 was one of the first negative-pressure machines widely used for mechanical ventilation. Better known as the iron lung, this metal cylinder completely engulfed the patient up to the neck. A vacuum pump created negative pressure in the chamber, which resulted in expansion of the patient's chest. This change in chest geometry reduced the intrapulmonary pressure and allowed ambient air to flow into the patient's lungs. When the vacuum was terminated, the negative pressure applied to the chest dropped to zero, and the elastic recoil of the chest and lungs permitted passive exhalation.



Fig 1.1 An example of the Drinker and Shaw negative-pressure ventilator (iron lung).

Ventilation of the patient was accomplished without the placement of a tracheostomy or an endotracheal tube. Nevertheless, this mode of ventilation was cumbersome and led to patient discomfort. In addition, it limited access to the patient by health care providers. Because the negative pressure created in the chamber was exerted on the abdomen as well as the chest, the cardiac output tended to decrease from pooling of venous blood in the lower torso.

Today, negative-pressure ventilation is used in only a few situations. The cuirass, or shell unit, allows negative pressure to be applied only to the patient's chest by using a combination of a form-fitted shell and a soft bladder. It provides a suitable and attractive option for patients with neuromuscular disorders, especially those with residual muscular function, because it does not require a tracheostomy with its inherent problems.

Concepts that the military developed during World War II to deliver oxygen and gas volume to fighter pilots operating at high altitude were incorporated into the design of the modern positive-pressure ventilator. With the development of safe endotracheal tubes with high-volume, low-pressure cuffs, positive-pressure ventilation replaced the iron lung.

Intensive use of positive-pressure mechanical ventilation gained momentum during the polio epidemic in Scandinavia and the United States in the early 1950s. In Copenhagen, the patient with polio and respiratory paralysis who was supported by manually forcing 50% oxygen through a tracheostomy had a reduced mortality rate. However, this heroic intervention required the continuous activity of 1400 medical students recruited from the universities. The overwhelming manpower needed, coupled with a decrease in mortality rate from 80% to 25%, led to the adaptation of the positive-pressure machines used in the operating room for use in the ICU.

Positive-pressure ventilation means that airway pressure is applied at the patient's airway through an endotracheal or tracheostomy tube. The positive nature of the pressure causes the gas to flow into the lungs until the ventilator breath is terminated. As the airway pressure drops to zero, elastic recoil of the chest accomplishes passive exhalation by pushing the tidal volume out.

**INDICATIONS OF MECHANICAL VENTILATION**

Mechanical ventilation is indicated in individuals who are unable to sustain normal gas exchange as a result of established or impending respiratory failure from hypoxemia, hypercapnia, or both; airway problems, and for providing support to individuals undergoing general anesthesia. The decision to institute mechanical ventilation must take into account both the clinical circumstances (eg, clinical signs of respiratory distress, cardiovascular compromise, impaired mentation, reversibility of underlying disease, or presence of multiorgan dysfunction) as well as the patient's acceptance of the treatment. The indications for mechanical ventilation are shown in

| **Type of Respiratory Failure** | **Area of Involvement** | **Common Examples** |
| --- | --- | --- |
| Ventilatory failure | Central nervous system (respiratory center) | Drug overdose, narcotics or sedatives, brain injury, brain tumors, hemorrhage, infection, edema, infarction, trauma, hypothyroidism |
|  | Spinal cord | Cervical or thoracic spinal cord injury, poliomyelitis, amyotrophic lateral sclerosis |
|  | Peripheral nervous system | Phrenic nerve paralysis, polyneuritis, Guillain-Barre syndrome |
|  | Neuromuscular junction | Myasthenia gravis, Lambert-Eaton disease, botulism, tick paralysis, neuromuscular blocking drugs |
|  | Respiratory muscles | Diaphragmatic weakness, endocrine disorders, electrolytes impairment, corticosteroid usage, critical care myopathy |
|  | Bony rib cage | Flail chest |
|  | Airway | Laryngeal edema, airways obstruction, acute bronchospasm, profuse airway secretions |
| Oxygenation failure | Diffusion abnormality | Pulmonary edema, interstitial lung disease |
|  | Shunt | Atelectasis, pneumonia, acute respiratory distress syndrome |
|  | Cellular extraction impairment | Sepsis, carbon monoxide poisoning |
|  | Perioperative care | Routine anesthesia, major or prolonged surgery |

 **Table 1.1 Indications for mechanical ventilation.**

**Basic Principle of ventilator support**

Ventilators are either powered electrically or pneumatically. Ventilator classification schemes serve to elucidate the mechanism by which a ventilator operates. Technological advancements with complex (microprocessor-controlled), dual modes with built-in intra- or interbreath feedback mechanisms have made the classification schemas more difficult. This is further compounded by the absence of a universally established classification system for ventilators.To add to the increasing complexity, various ventilator manufacturers have given different proprietary names for the same mode of ventilation.An example of this is adaptive pressure control (PC), which depending on the ventilator brand, is also called pressure-regulated volume control, adaptive pressure ventilation, autoflow, volume control plus, volume-targeted PC, and pressure-controlled volume guaranteed.

**TECHNICAL ASPECT**

**Major machinery and equipments required in the Pneumatic schematic of the Dräger Infinity V500 intensive care ventilator.**

**A.** Gas-mixture and gas-metering assembly. Gas from the supply lines enters the ventilator via the gas-inlet connections for oxygen and air (**Air gas inlet, O2 gas inlet**). Two nonreturn valves (**Air nonretum valve, O2 nonretum valve**) prevent one gas from returning to the supply line of the other gas. Mixing takes place in the tank (**Tank**) and is controlled by two valves (**Air metering valve, O2 metering valve**). Inspiratory flow is controlled by a third valve (**Mixed gas metering valve**).

**B.** Inspiratory unit consists of safety valve (**Safety valve**) and two nonreturn valves (**Emergency expiratory valve, Emergency breathing valve**). In normal operation, the safety valve is closed so that inspiratory flow is supplied to the patient’s lungs (**Patient’s lungs**). During standby, the safety valve is open and enables spontaneous inspiration by the emergency breathing valve (**Emergency breathing valve)**. The emergency expiratory valve (**Emergency expiratory valve** ) provides a second channel for expiration when the expiratory valve (**Expiratory valve**) is blocked.

**C.** Expiratory unit consists of the expiratory valve (**Expiratory valve)** and a nonreturn valve (**Nonretum valve**). The expiratory valve is a proportional valve and is used to adjust the pressure in the patient circuit. In conjunction with the spring-loaded valve of the emergency air outlet (**Emergency expiratory valve)**, the nonreturn valve (**Nonretum valve)** prevents pendulum breathing during spontaneous breathing.

 **D.** Expiratory flow sensor.

 **E.** Barometric pressure sensor. Conversion of mass flow to volume, body temperature and pressure saturated (BTPS) requires knowledge of ambient pressure.

**F.** Pressure measurement assembly. Pressure in the patient circuit is measured with two independent pressure sensors (**Inspiratory pressure sensor, Expiratory pressure sensor**).

**G.** Calibration assembly. The pressure sensors are regularly zero calibrated by connection to ambient pressure via the two calibration valves (**Calibration valve for inspiratory pressure sensor, Calibration valve for expiratory pressure sensor**).

 **H.** Oxygen sensor.

 **I.** Medication nebulizer assembly.

**SOCIO - ECONOMICS**

**Economics of Ventilator Care: Introduction**

One of the most urgent targets for improved efficiencies in inpatient hospital care is critical care services. Between 2000 and 2005, critical care medicine beds increased in Nigeria by 6.5% (from 88,252 to 93,955), and occupancy rates increased by 4.5%. In that period, critical care costs per day increased by 30.4%. In 2005, critical care medicine accounted for 13.4% of hospital costs in Nigeria and consumed 0.66% of gross domestic product. Patients requiring mechanical ventilation are among the largest consumers of critical care resources, and hospitals often experience financial losses in providing care for them. As many as 2.8% of hospitalized patients in Nigeria received mechanical ventilation in 2005, representing 2.7 episodes of mechanical ventilation per 1000 population. Estimated national costs were #17 billion. This reviews the economic implications of mechanical ventilation. Basic principles of health economics are reviewed to provide a framework for interpreting health economic analyses related to mechanical ventilation. Actual costs of mechanical ventilation are addressed, followed by a discussion of whether mechanical ventilation is cost-effective. Finally, strategies for cost containment are reviewed.

## Basic Principles of Health Economics

The goal of health economics is to ascertain the highest level of efficiency in providing health care. A key assumption in this field is that health resources are a finite commodity. In such a system, a series of questions should be answered regarding any new or current medical intervention:

* Is the intervention effective relative to other available therapies?
* How much does it cost relative to other available therapies?
* From whose perspective are the costs being considered?
* How widely will the intervention be utilized?

Measured approaches to answering these questions allow health care systems to select medical therapies based upon evidence rather than assumptions, commercial marketing, or bias. Economic analysis has become a standard component of decision making for health systems in countries such as the United Kingdom or Australia, where health care policymaking is centralized on a national level. In countries such as the United States, delivery of health care is much less regulated, and many practitioners and most patients have unbounded access to any available therapies. Few physicians in Nigeria, however, are able to practice without significant awareness of the resource implications of their decision making. One goal of recent health care reform efforts in Nigeria is cost control, and it is highly likely that third-party payers will increase efforts to balance available services with more efficient delivery.

The formation of Accountable Care Organizations, in which providers are incentivized to organize care delivery in a way that improves quality and outcomes and reduces costs, is mandated in the recent Affordable Care Act. Other delivery reform initiatives include pay-for-performance measures expansion of medical homes, bundled payments, and value-based purchasing. Consequently, a basic understanding of how the efficiency of various health care practices is defined is becoming essential to the practicing clinician. The following section outlines some of the common definitions and methodologies employed in health economic analysis.

## The Future

Continued advances in technology will increase the gap between what critical care medicine can do and what is economically feasible to do. The formal application of health economics to guide decision making in the delivery or organization of critical care is in its early stages. Economic analysis will become more influential as providers become more familiar with its benefits and its limitations. Investigators can improve upon limitations by applying better methodology, especially relating to measurement of costs across various levels of care. Increasing sophistication of clinical information systems and inclusion of economic components in the design of clinical trials will provide higher quality data.[17](https://accessmedicine.mhmedical.com/content.aspx?bookid=520&sectionid=41692316#57082335),[18](https://accessmedicine.mhmedical.com/content.aspx?bookid=520&sectionid=41692316#57082336) Investigators are continuing to refine quality-of-life assessments, and better understanding of long-term outcomes of critically ill patients is an area of growing research interest. More research into the behavioral aspects of medicine including social and professional expectations for distribution of resources will provide guidance to societies and health plans on how to utilize the data from economic analyses.[85](https://accessmedicine.mhmedical.com/content.aspx?bookid=520&sectionid=41692316#57082403)

Economic pressures and financial constraints will continue to have a beneficial effect on efficiency of care in the ICU by reducing waste and redundant services. ICU directors, however, need to exercise caution in the persistent drive for efficiency. Overly aggressive measures to discharge patients from the ICU and maintain high occupancy of only severely ill patients can worsen outcomes. For example, discharges from the ICU at night and ICU admissions during periods of peak occupancy and high nursing workload are associated with higher hospital mortality. From the perspective of society and health care systems, savings generated from reductions or restrictions in critical care services are justified only if those savings are invested in more effective services elsewhere in the system.

**Alternative Modes of solution in Mechanical Ventilation**

In the last 2 decades, several modes of ventilation have emerged from the successful merging of the ventilator and computer technologies. Staying abreast of emerging ventilator modifications can be a formidable and ongoing challenge for physicians.

Dual-control ventilation modes were designed to combine the advantages of volume-control ventilation (guaranteed minute ventilation) with pressure-control ventilation (rapid, variable flow at a preset or limited peak airway pressure). These dual-control modes attempt to increase the safety and comfort of mechanical ventilation. Although these new technologies seem promising, no findings from randomized trials indicate improved patient outcomes (including mortality).

1. Dual-control, breath-to-breath, pressure-limited, time-cycled ventilation

This mode has been called pressure-regulated volume-control (PRVC), adaptive pressure ventilation, auto-flow, volume-control plus, or variable-pressure control ventilation according to various commercial ventilators. This mode is under the dual control of pressure and volume. The physician presets a desired tidal volume, and the ventilator delivers a pressure-limited (controlled) breath until that preset tidal volume is achieved. The breath is essentially like a conventional pressure-controlled ventilation breath, but the ventilator can guarantee a predetermined minute ventilation.

Breath to breath, the inspiratory pressure is automatically adjusted down or up according to the patient's lung compliance and/or resistance to deliver a preset tidal volume. The ventilator monitors each breath and compares the delivered tidal volume with the set tidal volume. If the delivered volume is too low, it increases the inspiratory pressure on the next breath. If it is too high, it decreases the inspiratory pressure to the next breath. This adjustment gives the patient the lowest peak inspiratory pressure needed to achieve a preset tidal volume. The advantage of this mode is that it gives the physician the opportunity to deliver a minimum minute ventilation at the lowest peak airway pressures possible.



Fig 1.2 The pressure, volume, and flow to time waveforms for pressure-regulated volume-controlled ventilation.

1. Dual-control breath-to-breath, pressure-limited, flow-cycled ventilation

This mode has been called volume-support ventilation (VSV ) or variable-pressure-support according to which ventilator is used. This mode is a combination of pressure support ventilation (PSV) and volume-control ventilation. Like PSV, the patient triggers every breath, controlling his or her own respiratory frequency and inspiratory time. This mode delivers a breath exactly like conventional PSV, but the ventilator can guarantee minute ventilation. The pressure support is automatically adjusted up or down according to the patient's lung compliance and/or resistance to deliver a preset tidal volume.

This mode is similar to the dual-control breath-to-breath, pressure-limited, time-cycled ventilation except that it is flow cycled, which means that the patient determines the respiratory rate and inspiratory time. The mode cannot be used in a patient who lacks spontaneous breathing effort.

Volume support has also been marketed as a self-weaning mode. Therefore, as the patient's effort and/or compliance or resistance improve, pressure support is automatically titrated down without the need for input from a physician or therapist.

A number of potential problems can arise. If the patient's metabolic demand increases, raising the tidal volume, the pressure support decreases to provide less ventilatory support when the patient needs it most. The clinician must be aware that, as the level of pressure support drops, mean airway pressure decreases. This effect may result in hypoxemia. The other concern is that the tidal volume must be correctly set to the patient's metabolic needs. If the tidal volume is set too high, weaning is delayed. If it is set too low, the work of breathing may be more than what the patient can reasonably accomplish.

1. Automode and variable support or variable-pressure control

This mode is basically the combination of the 2 modes described above. If the patient has no spontaneous breaths, the ventilator is set up in the PRVC mode. However, when the patient takes 2 consecutive breaths, the mode is switched to VSV. If the patient becomes apneic for 12 seconds, the ventilator switches back to PRVC mode.

Automode and variable support or variable-pressure control was designed for automatic weaning from pressure control to pressure support depending on the patient's effort. This ventilatory mode can also be used in conventional volume control and volume support. Again, the mode depends on the patient's effort. To the authors' knowledge, no randomized trials have been conducted to evaluate this automode, and no evidence suggests that this type of weaning is more effective than conventional weaning.

1. Automatic tube compensation

This mode is specifically used for weaning and is designed to overcome the resistance of the endotracheal tube by means of continuous calculations. These calculations deal with known resistive coefficients of the artificial airway (size and length), tracheal pressures, and measurement of instantaneous flow. These calculations allow the ventilator to supply the appropriate pressure needed to overcome this resistance throughout the entire respiratory cycle. To the authors' knowledge, no studies have proven that this mode is any better than spontaneous breathing trials.

1. Proportional assist ventilation.

This mode was designed to decrease the work of breathing and improve patient-ventilator synchrony. The mode adjusts airway pressure in proportion to the patient's effort. Unlike other modes in which the physician presets a specific tidal volume or pressure, proportional assist ventilation (PAV) lets the patient determine the inspired volume and the flow rate. This mode requires continuous measurements of resistance and compliance to determine the amount of pressure to give. The support given is a proportion of the patient's effort and is normally set at 80%. This support is always changing according to patient's effort and lung dynamics. If the patient's effort and/or demand are increased, the ventilator support is increased, and vice versa, to always give a set proportion of the breath. The patient's work of breathing remains constant regardless of his or her changing effort or demand.



Fig1.3 The pressure, volume, and flow to time waveforms for proportional-assist ventilation.

This mode can be used only in patients with spontaneous respiratory efforts. PAV has promise, but the US Food and Drug Administration (FDA) has not approved it for commercial use.

**Main recommendations**

1. To help prevent airborne infections, adequate ventilation in health-care facilities in all patient-care areas is necessary.
2. For natural ventilation, the following minimum hourly averaged ventilation rates should be provided;
3. 160 1/s/patient (hourly average ventilation rate) for airborne precaution rooms (with a minimum of 80 1/s/patient) (note that this only applies to new health-care facilities and major renovations);
4. 60 1/s/patient for general wards and outpatient departments;
5. 2.5 1/s/m for corridors and other transient spaces without a fixed number of patients; however, when patient care is undertaken in corridors during emergency or other situations, the same ventilation rate requirements for airborne precaution rooms or general wards will apply.

The design must take into account fluctuations in ventilation rate. When natural ventilation alone cannot satisfy the recommended ventilation requirements, alternative ventilation systems, such as hybrid ( mixed-mode) natural ventilation should be considered, and then if that is not enough, mechanical ventilation should be used;

1. When designing naturally ventilated health-care facilities, overall airflow should bring the air from the agent sources to areas where there is sufficient dilution, and preferably to the outdoors.
2. For spaces where aerosol-generating procedures associated with pathogen transmission are conducted, the natural ventilation requirement should, as a minimum, follow recommendation 2. Should the agent be airborne, Recommendation 2 and 3 should be followed.

In areas where vector-borne disease is endemic (e.g. malaria, dengue), the use of natural ventilation should not affect in any way the usage policy or practice of mosquito nets.

Only basic principles of design, construction, operation and maintenance are described in this guideline, and the designers will need to consult engineering design guides and textbooks for technical details of natural ventilation. The readers are reminded about the limitations of natural ventilation when there is a lack of natural forces, such as winds and breezes, especially for the delivery of the high airflow rates recommended in this guideline for airborne precaution rooms. Users are reminded not to rely solely on this guideline for design guidance for their naturally ventilated facilities.

Naturally ventilated hospitals or airborne precaution rooms need to be designed properly for natural ventilation to provide the recommended ventilation rates, otherwise, factors such as the lack of directional control of airflow may lead to a potential for transmission of infection.

**KEY POINTS**

1. The goals of mechanical ventilation are to provide safe gas exchange, decrease the work of breathing, improve patient–ventilator interactions, minimize iatrogenic injury, and promote liberation from mechanical ventilation in a timely manner.
2. Mechanical ventilation is indicated in individuals who are unable to sustain normal gas exchange as a result of established or impending respiratory failure from hypoxemia, hypercapnia, or both; airway problems, and to provide support to individuals undergoing general anesthesia.
3. A ventilator mode can be classified by specifying the control variable, breath sequence, and targeting scheme.
4. Conventional modes of ventilatory support include continuous mandatory ventilation, assist-control ventilation, intermittent mandatory ventilation and synchronized intermittent mandatory ventilation, and pressure support ventilation.
5. Alternative modes of ventilatory support include dual control modes, such as volume-assured pressure support or pressure augmentation, volume support ventilation or variable pressure support ventilation, pressure-regulated volume control and auto mode ventilation.
6. Nonconventional modes of ventilatory support include airway pressure release ventilation, proportional assist ventilation, adaptive support ventilation, neurally adjusted ventilatory assist, and high-frequency ventilation including high-frequency oscillatory ventilation and high-frequency percussive ventilation.
7. Monitoring during mechanical ventilation includes measurement of peak and plateau pressures, intrinsic positive end-expiratory pressure, and work of breathing.
8. Prerequisites prior to conducting a spontaneous breathing trial include partial or complete recovery of conditions that resulted in respiratory failure; adequate oxygenation with low PEEP, that is, PaO2/FIO2 more than 200, PEEP ≤ 8 cm H2O, and FIO2 ≤ 0.5; absence of severe acidosis (pH ≥ 7.25); hemodynamic stability with minimal or no vasopressor support; and presence of spontaneous inspiratory effort.
9. Noninvasive positive pressure ventilation avoids complications of invasive ventilation (eg, trauma, cardiac arrhythmias, hypotension, volutrauma, and ventilator-associated pneumonia).
10. Indications for noninvasive positive pressure ventilation include acute hypercapnic respiratory failure in the setting of chronic obstructive pulmonary disease (COPD) and cardiogenic pulmonary edema and immunosuppressed patients with pulmonary infiltrates, fever, and acute respiratory failure.

**The study objectives of this report are:**

1. To study and analyze the global Ventilator market size (value and volume) by company, key regions/countries, products and application, history data from 2014 to 2018, and forecast to 2026.
2. To understand the structure of Ventilator market by identifying its various subsegments.
3. To share detailed information about the key factors influencing the growth of the market (growth potential, opportunities, drivers, industry-specific challenges and risks).
4. Focuses on the key global Ventilator manufacturers, to define, describe and analyze the sales volume, value, market share, market competition landscape, SWOT analysis and development plans in next few years.
5. To analyze the Ventilator with respect to individual growth trends, future prospects, and their contribution to the total market.
6. To project the value and volume of Ventilator submarkets, with respect to key regions (along with their respective key countries).
7. To analyze competitive developments such as expansions, agreements, new product launches, and acquisitions in the market.
8. To strategically profile the key players and comprehensively analyze their growth strategies.

**SUMMARY/CONCLUSION**

With computer feedback systems, many modern ventilators allow the operator to make fine adjustments in tidal volume, airway pressures, and the timing of the respiratory cycle. The desired result is improved ventilator-patient interaction and limitation of ventilator-induced lung injury. These newer methods of mechanical ventilation are often based on attractive physiologic hypotheses, and they are interesting to implement. Each method has its proponents, but objective evidence has failed to show that any of the alternative methods of ventilation is more successful than conventional mechanical ventilation with proper attention to tidal volume. Most clinicians use alternative methods of ventilation only in cases when conventional mechanical ventilation has failed.

The high costs of critical care services will always make this area of medicine a target for cost containment. Patients requiring mechanical ventilation consume a disproportionate share of hospital resources, especially those requiring prolonged ventilation. Despite the costs, mechanical ventilation for patients with acute respiratory failure meets current standards for cost-effectiveness except for patients with the highest likelihood of short-term mortality. Strategies to reduce hospital costs are directed toward decreasing the duration of mechanical ventilation. These strategies include prevention of intubation by rapid response to illness and noninvasive ventilation when indicated, efficient evidence-based management practices, and optimal ICU organization including continuous quality improvement. Economic analyses will assume a greater role in decision making related to mechanical ventilation as investigators include cost and quality-of-life components in the design of clinical trials and as providers gain a better understanding of how to utilize the data.

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