drones

MDPI

Communication

Drone Usage for Medicine and Vaccine Delivery during the COVID-19 Pandemic: Attitude of Health Care Workers in Rural Medical Centres

Rohana Sham [1], Ching Sin Siau [2,*], Steven Tan [3], Dawn Chii Kiu [4], Hasminulhadi Sabhi [5], Hui Zhu Thew [6], Ganeshsree Selvachandran [1], Shio Gai Quek [1], Noorsiah Ahmad [1] and Mohd Hanif Mohd Ramli [7]

1 Faculty of Business and Management, UCSI University, Jalan Menara Gading, Cheras, Kuala Lumpur 56000, Malaysia; rohana@ucsiuniversity.edu.my (R.S.); Ganeshsree@ucsiuniversity.edu.my (G.S.); queksg@ucsiuniversity.edu.my (S.G.Q.); noorsiahahmad@ucsiuniversity.edu.my (N.A.)
2 Centre for Community Health Studies, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, Kuala Lumpur 50300, Malaysia
3 Hospital Tuanku Ampuan Jemaah, Jalan Hospital, Sabak Bernam 45200, Selangor, Malaysia; drsteven@moh.gov.my
4 Hospital Rajah Charles Brooke Memorial, Batu 13, Jalan Puncak Borneo, Kota Padawan, Kuching 93250, Sarawak, Malaysia; kiu.dawnchii@moh.gov.my
5 Hospital Marudi, Jalan Pungor, Marudi, Baram 98050, Sarawak, Malaysia; hasminulhadi@moh.gov.my
6 Department of Family Medicine, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia; jothew@upm.edu.my
7 Sport Engineering and Artificial Intelligence Center, School of Mechanical Engineering, College of Engineering, UiTM Shah Alam, Shah Alam 40450, Selangor, Malaysia; haniframli@salam.uitm.edu.my
* Correspondence: chingsin.siau@ukm.edu.my

check for updates

Citation: Sham, R.; Siau, C.S.; Tan, S.; Kiu, D.C.; Sabhi, H.; Thew, H.Z.; Selvachandran, G.; Quek, S.G.; Ahmad, N.; Ramli, M.H.M. Drone Usage for Medicine and Vaccine Delivery during the COVID-19 Pandemic: Attitude of Health Care Workers in Rural Medical Centres. *Drones* **2022**, *6*, 109. https://doi.org/10.3390/drones6050109

Academic Editors: Paul Royall and Diego González-Aguilera

Received: 2 March 2022
Accepted: 24 April 2022
Published: 27 April 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: Rural areas are often difficult to access reliably with medicine and vaccines. This study aimed to examine rural health care workers' attitude towards drone delivery for medicine and vaccines and the factors that influenced it. Health care workers from four rural health care facilities were sampled. Participants self-reported their demographic information, attitude towards medicine and vaccine delivery using drones, perception of benefits and risks of using drones, and perceived leadership innovativeness through an online or a pen-and-paper questionnaire. A total of 272 health care workers (mean age = 36.19, *SD* = 8.10) from all of the sites participated in this study. More than half of the study participants agreed or strongly agreed that using a drone to deliver medicine and vaccines is a good idea (54.2%, 95% CI [47.5, 60.8]), a wise idea (54.6%, 95% CI [47.9, 61.2]), and is desirable (52.5%, 95% CI [45.7, 59.0]). Males (β = 0.223), workers from the Obstetrics and Gynaecology department (β = 0.135), a lower perceived delivery risk (β = −0.237), and higher leadership innovativeness (β = 0.336) predicted positive attitudes towards drone usage. Assistant medical officers (β = −0.172) had a negative attitude. There is a need to further understand the roles of occupation and leadership innovativeness in predicting health care workers' attitude towards drone usage, as these differences could be embedded within their roles in the health care system.

Keywords: drone delivery; rural; vaccine; medicine health care worker; attitude; COVID-19

1. Introduction

Accessibility is a fundamental prerequisite for sustainable development, as an intrinsic right and condition of living. People living in rural areas face major challenges due to long distances between the community and the nearest health facility, be it a health centre, district hospital, or central hospital. People living in rural areas also face less reliable access to transport and facilities [1]. Most of the rural areas are often difficult to access; thus, logistics processes become complicated, and local contracting capability is limited [2].

A recent study [3] had also concluded that rural territories often suffer from scarce and inadequate access to basic services, amenities, and opportunities, resulting in territorial and socioeconomic marginalisation. This was previously supported by [1], who had confirmed that transport and health are inextricably linked.

In terms of demographics, 23.9% of Malaysians live in rural areas in about 26,400 villages. There continues to be a gap between rural and urban household incomes, in which the gross monthly income of household by strata was RM4359 (USD1032) in rural areas and RM7671 (USD1816) in urban areas [4]. There is an annual growth of 1.8 percent for those above the age of 65, which means the rural population is ageing faster than the urban population [4]. Even though absolute poverty is largely a thing of the past, the prevalence of low socioeconomic status is higher in rural areas in Malaysia [5]. Apart from income, there appears to be a gap in the health status of the rural population. For example, according to the National Health and Morbidity Survey 2015, the rural population has about 3% more cases of hypercholesterolemia, at 33.5%, compared to the urban population at 29.3% [6].

Medical technologies are fast developing and enable solutions to the problems that still exist. Medical technologies in health care include automatisation and robotisation in the delivery of medical services, the use of information technology in maintaining hospital records, and artificial information to make diagnoses [7]. Unmanned aerial vehicles or drones are fast becoming a health care technology application; these have been used in various ways, such as search-and-rescue in natural disasters, the transport of blood samples, and even the delivery of vaccines and medications to rural areas [8,9].

To overcome disparities in health care provision, the use of medical technology should be disseminated to rural areas. Malaysia faces various obstacles to providing health services to rural communities, including disparities in population density, accessibility, and accessible service types. About two-thirds of public clinics in Malaysia are located in rural areas. Nevertheless, a study has revealed that the distribution of health care services is unequal and has favoured urban areas [10]. For example, in terms of government and private clinics, the distribution in rural areas was 1.1 per 10,000 population, whilst in urban areas, it was 2.2 per 10,000 population [10]. Although transportation has long been cited as a concern for rural residents, reported rural transportation challenges are rarely the focus of health services research [11]. As a social determinant of health, access to high-quality, affordable transportation is fundamental to mental, physical, and emotional well-being. Thus, this problem leads to a huge gap between the people who are living in rural areas. They will face major challenges due to the long distances between the community and the nearest health facility [1].

With the option of drone delivery services available, deliveries could be done in a quicker and eco-friendlier manner at a reduced cost, as compared to traditional delivery options, such as vans and trucks [12]. The transformation of the delivery method has the potential to replace manual delivery. Using the drone system may help to achieve automatic, unmanned, and information-based delivery in order to improve delivery efficiency and service quality. This will bridge the gap between the demand for order and delivery service capability.

Health care workers are at the forefront of medical technology acceptance. They will be one of the main players in managing and delivering the services to the general public. A study in Oslo, Norway, showed that that health care workers have a positive attitude towards the usage of drones [7]. Especially in the era of COVID-19, there is a more urgent need to reach rural areas with vaccines using a fast but safe manner. Several studies have explored the possibility of using drones to deliver COVID-19 vaccines to inaccessible areas [13,14]. A few studies had studied consumer acceptance of drone delivery during the pandemic; these studies, however, had focused on the attitudes towards general goods or food delivery [15,16]. There is, therefore, a need to explore the attitude of health care workers towards drone delivery of medicines and vaccines during the COVID-19 pandemic. Drones are currently being explored in Malaysia for use in delivering medicines and vaccines. However, there is a lack of studies addressing rural health care workers'

acceptance of drones as a mode of delivery of vaccines and medicines to rural areas. In addition, health care workers are already burdened with various responsibilities [17].

Rural health care will benefit greatly from the development of alternative delivery options, such as using drone delivery. This study was a substudy of an Industry Promotion and Development Grant titled "Designing a Green Delivery Network for Medicine and Vaccine Delivery in Rural Areas Using Drone" (refer to Funding section and Supplementary Material S1). The original study had outlined the development and testing for delivering medicine and vaccines in rural areas using the Visual Line of Sight (VLOS) and Extended Visual Line of Sight (EVLOS) operational methods as prototypes. In addition, we developed a platform for placing and tracing orders and managing the delivery fleet. This includes placing an order by scanning a QR code, submitting an order to the delivery supervisor to decide on the suitable drone and container to be deployed, notifying the user when the parcel is being delivered, and notifying the delivery company when the parcel has been received (refer to Supplementary Material S1 for more details). However, the VLOS and EVLOS operational methods were shown to be inadequate for vaccine and medicine delivery in rural areas [18,19]. Therefore, when envisioning a future possibility of delivering vaccines and medicine in rural Malaysia, using a Beyond Visual Line of Sight (BVLOS) is more appropriate. Based on the BVLOS operating concept, in this substudy, we aim to examine rural health care workers' attitude towards drone delivery for medicine and vaccines, and the factors that influenced it during the COVID-19 pandemic. To our best knowledge, this is the first study addressing rural health care workers' attitude towards drone delivery conducted during the COVID-19 pandemic.

2. Materials and Methods

2.1. Study Design

This is a cross-sectional study.

2.2. Study Location

The study was held in one district health clinic (Klinik Kesihatan Pengkalan Hulu in Perak) and three district hospitals without specialists (Hospital Sabak Bernam in Selangor, Hospital Raja Charles Brooke Memorial in Sarawak, and Hospital Marudi in Sarawak). The study sites were appropriate as they were identified as district hospitals and a district clinic that were indicative of their rural locality.

2.3. Sample Size

Based on the recommendation by Tabachnick and Fidell [20] for performing a regression analysis, the rule-of-thumb formula of 50 + 8 m (where m = number of predictors) was used to calculate the sample size. Based on this assumption, there should be at least 196 participants recruited from these health centres. Inclusive of a drop-out rate of 20%, 235 participants in total were targeted.

2.4. Participants and Sampling Method

Universal sampling was used to recruit all hospital/clinic staff from the sites. The inclusion and exclusion criteria of health care workers to be involved in this study were as follows: aged 18 years old and above, hospital-based occupations (Medical Officer, Assistant Medical Officer, Nurse, Pharmacist/Assistant Pharmacist, or Attendant/Administrator in the clinic/hospital), and the health care worker has served in the hospital/clinic for at least 6 months. Exclusion criteria were: not able to read Bahasa Malaysia and English (Form 3 level) and not willing/able to provide informed consent.

2.5. Measures

Demographic sheet: The following information were collected from the demographic sheet: age, gender, ethnicity, religion, marital status, occupation, department, hospital/clinic where they are working, and highest education attained.

Drone Acceptance Questionnaire: The questionnaire developed by Yoo et al. [12] measured the factors affecting consumers' attitudes towards drone delivery and their intention to adopt it. We adapted the questionnaire to specifically address attitude towards drone delivery of medicine and vaccines. The final questionnaire consists of 30 items answered on a five-point Likert scale ranging from "strongly disagree-1" to "strongly agree-5" (see Supplementary Material S2). The domains were (1) attitude towards drone delivery of vaccines and medicine, (2) intention to use drone to deliver vaccines and medicine, (3) advantage of speed, (4) advantage of environmental friendliness, (5) compatibility with lifestyle, (6) complexity of using drone for the delivery of vaccines and medicine, (7) performance risk, (8) delivery risk, and (9) personal innovativeness. The original questionnaire had demonstrated acceptable convergent and discriminant validity, as well as reliability of Cronbach's alpha ranging from 0.752–0.975. In the current study, the domains of personal innovativeness ($\alpha = 0.598$) and performance risk ($\alpha = 0.655$) were excluded from further analysis due to an internal consistency reliability of less than 0.70. The remaining domains recorded the internal consistency reliability, which ranged from 0.868–0.954.

Innovative leadership: Two questions on perceived leadership innovativeness were added to the questionnaire. They were: "My leader supports innovative ideas" and "My leader is open to innovative ideas," adapted from Comtet and Johannessen [7] and answered on a five-point Likert scale ranging from "strongly disagree-1" to "strongly agree-5". They were found to have a good internal consistency reliability to form the domain of innovative leadership influence ($\alpha = 0.846$).

2.6. Procedures

All questionnaires were forward–backward translated into Malay independently by two linguistic and two subject matter experts. A harmonisation meeting between the researchers determined the final version of the Malay questionnaire.

Permission to approach participants was obtained from the director of each hospital and the head of each department. Participants were approached using two modalities: an online survey (Hospital Marudi and Hospital Raja Charles Brooke Memorial) and a pen-and-paper survey (Sabak Bernam Hospital and Pengkalan Hulu Health Clinic). The researcher briefed the participants on the aim and procedures of this study. Participants were given sufficient time to consider their participation in the study. Upon obtaining informed consent, the questionnaires were distributed in hard or soft copy to each of the health care workers. Filling out the questionnaire would take approximately 15 min. The researcher approached the participant again the next day to collect the questionnaire in hard copy or to remind them to fill out the online questionnaire.

Data was processed using IBM SPSS for Windows, Version 25 (SPSS Inc.: Armonk, NY, USA). The normal distribution of the data was established using skewness and kurtosis values of $< \pm 2$. The independent samples *t*-test and one-way ANOVA were used to test whether there were significant differences in attitude towards drone usage in terms of gender, age, occupation, department, and the hospital/clinic where they were working. We had included gender and age in the analysis because a past study in Germany found that males and younger participants had a more positive attitude towards the adoption of civil drones than females and older participants, respectively [21]. The correlations between the continuous variables were tested using Pearson's correlation. Predictors that were significantly associated with attitudes towards drone usage were included in a multiple linear regression model. All two-tailed statistical analyses were deemed significant at $p < 0.05$.

3. Results

A total of 272 health care workers (mean age = 36.19, *SD* = 8.10) from all of the sites participated in this study between April and September of 2021. Most of the participants were female (77.5%), aged 30–39 years old (49.3%), Malay (63.9%), married (78.4%), had a diploma (49.8%), nurses (47.6%), and from the medical department (30.0%). The demographic characteristics of the participants are reflected in Table 1 (refer to Table 1).

Table 1. Demographic variables and association with total drone acceptance scale (n = 227).

Variable	Number (n)	Percentage (%)	Attitude towards Using Drone			
			Mean	Standard Deviation	F/t Statistic (df)	p-Value
Institution					3.51 (3223)	**0.016** *
Hospital Tuanku Ampuan Jemaah, Selangor	100	44.1	9.62	2.86		
Hospital Memorial Raja Charles Brooke III, Sarawak	44	19.4	9.64	2.14		
Hospital Marudi, Sarawak	43	18.9	10.86	1.85		
Pengkalan Hulu Health Clinic, Perak	40	17.6	10.73	3.16		
Age (years)					1.253 (3221)	0.292
Mean (Standard Deviation)	36.19 (8.10)					
18 to 29	47	20.9	9.72	2.98		
30 to 39	111	49.3	10.38	2.60		
40 to 49	45	20.0	9.60	2.59		
50 to 59	22	9.8	9.86	2.49		
Gender					2.241 (225)	**0.026** *
Male	51	22.5	10.78	2.47		
Female	176	77.5	9.84	2.70		
Occupation					3.382 (4222)	**0.010** *
Medical Officer	21	9.3	10.81	2.09		
Nurse	108	47.6	10.52	2.46		
Assistant Medical Officer	20	8.8	9.75	2.83		
Hospital Attendant/Administrative Officer	35	15.4	9.66	3.20		
Pharmacist/Assistant Pharmacist	43	18.9	8.98	2.60		
Department					3.571 (5221)	**0.004** **
Medical	68	30.0	10.41	2.21		
Pharmacy	43	18.9	11.38	1.41		
Accident and Emergency	20	8.8	10.16	2.83		
Paediatrics	19	8.4	9.25	2.65		
Obstetrics and Gynecology	16	7.0	8.84	2.75		
Others	61	26.9	10.39	3.00		

Note. * significant at <0.05. ** significant at <0.01.

In terms of attitude towards using drones to deliver medicine and vaccines, more than half agreed or strongly agreed that using drone delivery for medicine and vaccines is a good idea (54.2%, 95% CI [47.5, 60.8]), is a wise idea (54.6%, 95% CI [47.9, 61.2]), and is desirable (52.5%, 95% CI [45.7, 59.0]). The results of the independent samples t-test and one-way ANOVA revealed that institution, gender, occupation, and department were significantly different in terms of attitude. The bivariate correlation showed that intention to adopt, advantage of speed, environmental friendliness, compatibility, complexity, delivery risk, and leadership influence correlated significantly with attitude towards drone usage. These significant variables were entered into the multiple linear regression to test the adjusted influence of each variable on attitudes towards drone acceptance. Furthermore, intention to adopt, advantage of speed, environmental friendliness, compatibility, and complexity had a strong correlation ($r > 0.7$) with attitude towards drone usage, and, therefore, were also excluded from further analysis (refer to Table 2).

The results of the multiple linear regression showed that the predictors accounted for a significant variability in attitude towards drone usage: $R^2 = 0.334$, adjusted $R^2 = 0.286$, $F(15,211) = 7.049$, $p < 0.001$. Males ($\beta = 0.223$), workers from the Obstetrics and Gynaecology department ($\beta = 0.135$), a lower perceived delivery risk ($\beta = -0.237$), and higher leadership innovativeness ($\beta = 0.336$) predicted positive attitudes towards drone usage to deliver medicine and vaccines. Conversely, assistant medical officers ($\beta = -0.172$) had a negative attitude towards drone usage (refer to Table 3).

Table 2. Correlational analysis of attitude towards drone delivery, intention to adopt drone for delivery of vaccines and medicine, and related factors.

Variable	Mean (*SD*)	Cronbach's α	1	2	3	4	5	6	7	8
Attitude (1)	10.05 (2.67)	0.921	-	0.878 ***	0.772 ***	0.746 ***	0.796 ***	0.764 ***	0.276 ***	0.351 ***
Intention to adopt (2)	9.65 (2.87)	0.954		-	0.847 ***	0.847 ***	0.898 ***	0.884 ***	0.252 ***	0.447 ***
Advantage of speed (3)	10.57 (2.60)	0.945			-	0.839 ***	0.817 ***	0.765 ***	0.183 **	0.413 ***
Environmental friendliness (4)	10.50 (2.46)	0.933				-	0.816 ***	0.782 ***	0.179 **	0.404 ***
Compatibility (5)	9.75 (2.63)	0.927					-	0.896 ***	0.237 ***	0.403 ***
Complexity (6)	9.44 (2.69)	0.923						-	0.267 ***	0.417 ***
Delivery risk (7)	6.56 (2.10)	0.868							-	0.024
Leadership influence (8)	7.28 (1.38)	0.846								-

Note. *** significant at <0.001. ** significant at <0.01.

Table 3. Multiple linear regression of factors affecting attitude towards drone acceptance.

Variable	B	95% Confidence Intervals		Beta	*p*-Value
		Upper	Lower		
Constant	3.590	1.294	5.886		
Institution					
Hospital Tuanku Ampuan Jemaah, Selangor	−0.436	−1.437	0.565	−0.081	0.391
Hospital Raja Charles Brooke Memorial, Sarawak	−0.617	−1.658	0.425	−0.091	0.245
Hospital Marudi, Sarawak	0.760	−0.375	1.894	0.112	0.188
Pengkalan Hulu Health Clinic, Perak (ref)					
Gender					
Male	**1.424**	**0.547**	**2.300**	**0.223**	**0.002 ** **
Female (ref)					
Occupation					
Medical Officer (ref)					
Nurse	−0.222	−1.432	0.989	−0.042	0.718
Assistant Medical Officer	**−1.617**	**−3.126**	**−0.108**	**−0.172**	**0.036 ***
Hospital Attendant/Administrative Officer	−1.079	−2.454	0.296	−0.146	0.123
Pharmacist/Assistant Pharmacist	−0.289	−2.514	1.935	−0.043	0.798
Department					
Medical	0.606	−0.252	1.465	0.104	0.165
Obstetrics and Gynecology	**1.403**	**0.067**	**2.738**	**0.135**	**0.040 ***
Paediatrics	0.456	−0.847	1.759	0.047	0.491
Accident and Emergency	−1.009	−2.293	0.275	−0.107	0.123
Pharmacy	−0.854	−2.892	1.184	−0.126	0.410
Others (ref)	0.606	−0.252	1.465	0.104	0.165
Delivery risk	**0.302**	**0.150**	**0.453**	**0.237**	**<0.001 *****
Leadership influence	**0.650**	**0.430**	**0.871**	**0.336**	**<0.001 *****

Note. *** significant at $p < 0.001$. ** significant at $p < 0.01$. * significant at $p < 0.05$. $R^2 = 0.334$, adjusted $R^2 = 0.286$, F (15,211) = 7.049, $p < 0.001$.

4. Discussion

This study aimed to investigate the attitude of rural health care workers towards drone delivery for medicine and vaccines, as well as the factors that influenced their attitude. The COVID-19 pandemic has brought an emphasis on contactless delivery options, such as drone delivery, in addition to reaching rural areas during a medical crisis with the required medicine and vaccines at a fast speed [22]. Overall, slightly more than half of the rural health care workers surveyed expressed a positive attitude towards drone usage. In comparison, another study on public attitude towards drone delivery also reflected an overall positive attitude towards its adoption (Mean = 3.65, *SD* = 1.20) [12]. A study in Norway showed that a majority (70%) of the health care staff believed drones were a viable

future option for medical transportation issues [7]. In contrast, the results of this study showed that the attitude towards drone usage was still mixed, and, therefore, there is a need to explore further the perceived barriers and facilitators towards its adoption.

Regarding health care workers' attitude towards adopting drones in medical parcel delivery, it appears that the most influential factor was an innovative leadership influence. The results could be explained by the high levels of power distance among Malaysians, where individuals unquestioningly accepted the presence of a powerful vs. powerless hierarchical order [23]. The healthcare setting itself exemplified a strong tendency for a greater power distance [24,25]. Therefore, perceived innovativeness of a leader may be crucial in the implementation of using drones for delivering medicine and vaccines in rural Malaysia. An innovative leader would be willing to support a new initiative such as this and also provide the resources to carry it out well. Alternatively, failure by the leadership to carry it out well may potentially lead to the failure of adopting drone usage.

The perceived delivery risk of using drones was the second most influential factor associated with attitude towards drone delivery of medicine and vaccines. The results of this study were not consistent with another study on drone usage for food delivery, where delivery risk was not associated with attitude and acceptance of drones for this purpose [26]. Concerns regarding the delivery risk experienced by drones, due to theft or damage, may be higher for the delivery of medicines and vaccines, in comparison with food delivery, because the former may involve controlled medicine or potentially toxic substances.

Males also recorded a more positive attitude towards drone usage. This may be because males have a higher risk acceptance in general [27], and, therefore, their perceptions of the benefits of drone usage may outweigh concerns about the risks. In addition, females from rural areas may be more susceptible to the gender divide in new technology acceptance [28,29]. This was perhaps a result of higher anxiety with regards to technology usage [30] or due to a higher emphasis on traditional gender norms and a lack of opportunity to use technology [31]. The results are consistent with other studies on public attitudes towards drones, whereby males reported greater support for drone usage [32]. In terms of the adoption of drones for medical transportation, a Norwegian study likewise demonstrated greater acceptance among males as compared to female health care employees.

Descriptive and univariate analysis showed that pharmacists/assistant pharmacists had a low mean score for the acceptance of drone usage. However, in the multiple linear regression, only assistant medical officers showed a negative attitude towards adopting drones in medicine and vaccine delivery. Notwithstanding the non-significant results, the negative attitude towards drone acceptance among pharmaceutical workers is of concern. This is because pharmacists would be more involved in the logistics and planning of a drone delivery system, through their expert input on the specifications of the medicines and vaccines to be delivered, such as ideal temperature, safe handling, storage, and legal concerns [33]. Their attitude may stem from their knowledge of the complexity of drone delivery of these goods. In contrast, a study among pharmacists in the UK revealed that a majority (73%) agreed to the use of drones in delivering an EpiPen® in anaphylaxis emergencies, especially among younger pharmacists [34]. Further studies need to explore, perhaps qualitatively, the perceived barriers that generated the relatively negative attitude of Malaysian rural pharmacy workers towards using drones to deliver medicine and vaccines. In addition, it would be beneficial to also explore the more negative attitudes of assistant medical officers towards drone usage in comparison with those of the medical officers.

This study has an impact on shaping policies and practices for the implementation of and recommendations for the adoption of drones in the rural health care sector for the delivery of medicine and vaccines. For example, by understanding that perceived leadership innovativeness is important, rural hospital and clinic directors could be encouraged to sign up their hospitals as drone-friendly hospitals for a pilot project implementing drone delivery. Limited understanding and fears regarding drone delivery among health care workers could be overcome by continuous education activities related to the medical logistics in-

volving drones. The benefits and challenges of using drones in medical delivery could be addressed during these activities. Best practices for implementing drone delivery in clinics and hospitals could be shaped through workshops involving all stakeholders. Finally, future research could focus on how to improve drone acceptance, not only among health care workers, but also among patients and their caregivers. During a health crisis such as the COVID-19 outbreak, innovative solutions for contactless, speedy, and cost-effective delivery systems become more viable. Rural areas could be reached quickly to deliver important vaccines and medicines that could combat life-threatening diseases. A study has found that time savings from using drones to deliver biologic samples to rural areas were between 65% and 74% when the drone speed is at 100 km/h [35]. However, the cost of time gains is offset by the fact that a lesser volume of goods and samples could be transported [35]. Understanding the enablers and barriers to implementing a drone delivery system for medicines and vaccines among its core stakeholder, the rural health care workers, is an important first step to its implementation. In our study, both the perceived beneficial and risk factors played their parts, and therefore both need to be taken into consideration.

There are a few limitations to this study. First of all, even though the study was carried out during the COVID-19 pandemic, we did not control for factors related to this pandemic. Due to the limited number of rural medical centres sampled in this study, and because they were chosen using the convenience sampling method, we were unable to generalise our results to all rural centres in Malaysia. Future studies could be more extensive by randomly selecting a representative sample of rural medical centres to enable better generalisation of the study. We did not explain to the participants the type of drone delivery we were conceptualising, and therefore depended on the participants' prior knowledge and conceptions about drone delivery. This has pros and cons. On the one hand, participants may have ideas about drones that do not match the current technology available. Therefore, their misconceptions may have caused bias in their responses. On the other hand, providing participants with information about our understanding of drone delivery may inadvertently produce bias. The information we provide may be favourable towards drone usage, leading to a more positive attitude towards using drones to deliver medicine and vaccines. We should also find out how perceptions of drone delivery may have been affected by the outbreak. For example, the pandemic may have tempered the perceived risk of drone delivery, as contactless delivery has been perceived to be more important after the outbreak [36]. Finally, as a cross-sectional study, cause-and-effect between the variables could not be established.

5. Conclusions

In conclusion, the main finding of this study was that slightly more than half of the rural health care workers surveyed had a positive attitude towards medicine and vaccine delivery using drones, indicating that the attitude towards drone usage was still mixed. Specifically, more than half agreed or strongly agreed that using drone delivery for medicine and vaccine is a good idea (54.2%), is a wise idea (54.6%), and is desirable (52.5%). Factors influencing their attitude include leadership innovativeness, perceived delivery risk, and being male. In addition, the perceived benefits of using drones, such as the advantage of speed, environmental friendliness, higher compatibility, and lower complexity were strongly correlated with a positive attitude. Of note, there is a need to further understand the role of occupation and department in predicting health care workers' attitude towards drone usage, as these differences could be embedded within their roles in the health care system. Understanding the factors influencing drone acceptance could help to tailor policies and practices that enable the adoption of drones into the delivery of medicine and vaccines to rural areas.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/drones6050109/s1, Supplementary Material S1: Demographic variables and association with total drone acceptance scale (n = 227); Supplementary Material S2: Correlational analysis of attitude towards drone delivery, intention to adopt drone for delivery of vaccine and medicine and related factors; Supplementary Material S3: Multiple linear regression of factors affecting attitude towards drone acceptance.

Author Contributions: Conceptualisation, R.S., C.S.S., G.S., S.G.Q., N.A. and M.H.M.R.; methodology, C.S.S.; software, C.S.S.; validation, R.S. and C.S.S.; formal analysis, C.S.S.; data curation, R.S., C.S.S., S.T., D.C.K., H.S. and H.Z.T.; writing—original draft preparation, C.S.S.; writing—review and editing, R.S., G.S., S.G.Q., N.A., M.H.M.R., S.T., D.C.K., H.S. and H.Z.T.; project administration, R.S.; funding acquisition, R.S. All authors have read and agreed to the published version of the manuscript.

Funding: The research was funded by the Industry Promotion and Development Grant, Malaysian Technical Standards Forum Bhd, grant number MTSFB/IPDG2020/GICT-02 and Skim Insentif Penerbitan Jurnal 2021 (GP-2021-K023687 (02)), Universiti Kebangsaan Malaysia.

Institutional Review Board Statement: All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki and the Malaysian Good Clinical Practice Guidelines, and the protocol was approved by the Medical Research and Ethics Committee (NMRR-21-514-58924), Ministry of Health Malaysia.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: We would like to thank the Director General of Health Malaysia for his permission to publish this article. We also thank the hospital directors and staff who permitted and assisted in this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Geoffroy, E.; Harries, A.D.; Bissell, K.; Schell, E.; Bvumbwe, A.; Tayler-Smith, K.; Kizito, W. Bringing care to the community: Expanding access to health care in rural Malawi through mobile health clinics. *Public Health Action* **2014**, *4*, 252–258. [CrossRef] [PubMed]
2. Woźniakowski, T.; Zmarzłowski, K.; Nowakowska, M. Automation and innovations in logistic processes of electronic commerce. *Inf. Syst. Manag.* **2018**, *7*, 72–82. [CrossRef]
3. Johnson, K.M.; Lichter, D.T. Rural depopulation: Growth and decline processes over the past century. *Rural Sociol.* **2019**, *84*, 3–27. [CrossRef]
4. Department of Statistics Malaysia. Press Release: Report of Household Income and Basic Amenities Survey 2016. Available online: https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=RUZ5REwveU1ra1hGL21JWVlPRmU2Zz09 (accessed on 12 January 2022).
5. Shahar, S.; Vanoh, D.; Ludin, A.F.; Singh, D.K.; Hamid, T.A. Factors associated with poor socioeconomic status among Malaysian older adults: An analysis according to urban and rural settings. *BMC Public Health* **2019**, *19*, e549. [CrossRef]
6. Institute for Public Health. Volume II National Health and Morbidity Survey 2015—Non-Communicable Diseases, Risk Factors & other Health Problems. Available online: https://iku.moh.gov.my/images/IKU/Document/REPORT/nhmsreport2015vol2.pdf (accessed on 12 January 2022).
7. Comtet, H.E.; Johannessen, K.A. The moderating role of pro-innovative leadership and gender as an enabler for future drone transports in healthcare systems. *Int. J. Environ. Res. Public Health* **2021**, *18*, 2637. [CrossRef]
8. Haidari, L.A.; Brown, S.T.; Ferguson, M.; Bancroft, E.; Spiker, M.; Wilcox, A.; Ambikapathi, R.; Sampath, V.; Connor, D.L.; Lee, B.Y. The economic and operational value of using drones to transport vaccines. *Vaccine* **2016**, *34*, 4062–4067. [CrossRef]
9. Rosse, J.C., Jr.; Vignesh, V.; Terwilliger, B.A.; Parker, B.C. Surgical and medical applications of drones: A comprehensive review. *J. Soc. Laparoendosc. Surg.* **2018**, *22*, e2018-00018.
10. Lim, H.M.; Sivasampu, S.; Khoo, E.M.; Mohamad Noh, K. Chasm in primary care provision in a universal health system: Findings from a nationally representative survey of health facilities in Malaysia. *PLoS ONE* **2021**, *12*, e0172229. [CrossRef]
11. Robert Wood Johnson Foundation. How does transportation impact health? *Rural Soc.* **2012**, *84*, 3–27.
12. Yoo, W.; Yu, E.; Jung, J. Drone delivery: Factors affecting the public's attitude and intention to adopt. *Telemat. Inform.* **2018**, *35*, 1687–1700. [CrossRef]

13. Panwar, A.; Sharma, N.; Garg, K.; Bahurupi, Y.; Singh, M.; Aggarwal, P. Mobile Vaccine Vans and Drones-the Future of Vaccination Delivery System. *J. Compr. Health* **2021**, *9*, 41–43. [CrossRef]
14. Sun, X.; Andoh, E.A.; Yu, H. A simulation-based analysis for effective distribution of COVID-19 vaccines: A case study in Norway. *Transp. Res. Interdiscip. Perspect.* **2021**, *11*, 100453. [CrossRef]
15. Yaprak, Ü.; Kılıç, F.; Okumuş, A. Is the COVID-19 pandemic strong enough to change the online order delivery methods? Changes in the relationship between attitude and behavior towards order delivery by drone. *Technol. Forecast. Soc. Chang.* **2021**, *169*, 120829. [CrossRef]
16. Kim, J.J.; Kim, I.; Hwang, J. A change of perceived innovativeness for contactless food delivery services using drones after the outbreak of COVID-19. *Int. J. Hosp. Manag.* **2021**, *93*, 102758. [CrossRef]
17. Siau, C.S.; Wee, L.H.; Ibrahim, N.; Visvalingam, U.; Ling Yeap, L.L.; Yeoh, S.H.; Wahab, S. Predicting burnout and psychological distress risks of hospital healthcare workers. *Malays. J. Public Health Med.* **2018**, *2018*, 125–136.
18. Fang, S.X.; O'Young, S.; Rolland, L. Development of small UAS beyond-visual-line-of-sight (BVLOS) flight operations: System requirements and procedures. *Drones* **2018**, *2*, 13. [CrossRef]
19. Andersen, F.M.; Terkildsen, K.H.; Schultz, U.P.; Jensen, K. Towards SORA-Compliant BVLOS Communication. In Proceedings of the 2021 International Conference on Unmanned Aircraft Systems (ICUAS), Athens, Greece, 15–18 June 2021; pp. 1509–1519. [CrossRef]
20. Tabachnick, B.G.; Fidell, L.S.; Ullman, J.B. *Using Multivariate Statistics*; Pearson: Boston, MA, USA, 2007.
21. Eißfeldt, H.; Vogelpohl, V.; Stolz, M.; Papenfuß, A.; Biella, M.; Belz, J.; Kügler, D. The acceptance of civil drones in Germany. *CEAS Aeronaut. J.* **2020**, *11*, 665–676. [CrossRef]
22. Sharma, M. Drone technology for assisting COVID-19 victims in remote areas: Opportunity and challenges. *J. Med. Syst.* **2021**, *45*, 85. [CrossRef]
23. Hofstede, G.; Hofstede, G.; Minkov, M. *Cultures and Organizations: Software of the Mind*, 3rd ed.; McGraw-Hill: New York, NY, USA, 2010.
24. Chan, C.M.; Ahmad, W.A.; Yusof, M.; Ho, G.F.; Krupat, E. Patient-centredness, job satisfaction and psychological distress: A brief survey comparing oncology nurses and doctors. *Asian Pac. J. Cancer Prev.* **2015**, *16*, 6895–6898. [CrossRef]
25. Siau, C.S.; Wee, L.H.; Wahab, S.; Visvalingam, U.; Yeoh, S.H.; Halim, N.A.; Ibrahim, N. The influence of religious/spiritual beliefs on Malaysian hospital healthcare workers' attitudes towards suicide and suicidal patients: A qualitative study. *J. Res. Nurs.* **2021**, *26*, 723–740. [CrossRef]
26. Mathew, A.O.; Jha, A.N.; Lingappa, A.K.; Sinha, P. Attitude towards drone food delivery services—role of innovativeness, perceived risk, and green image. *J. Open Innov. Technol. Mark. Complex* **2021**, *7*, 144. [CrossRef]
27. Byrnes, J.P.; Miller, D.C.; Schafer, W.D. Gender differences in risk taking: A meta-analysis. *Psychol. Bull* **1999**, *125*, 367. [CrossRef]
28. Chawla, D.; Joshi, H. The moderating role of gender and age in the adoption of mobile wallet. *Foresight* **2020**, *22*, 483–504. [CrossRef]
29. Orser, B.J.; Riding, A. The influence of gender on the adoption of technology among SMEs. *Int. J. Entrep. Small Bus.* **2018**, *33*, 51.
30. Lee, H.J.; Cho, H.J.; Xu, W.; Fairhurst, A. The influence of consumer traits and demographics on intention to use retail self-service checkouts. *Mark Intell. Plan* **2010**, *28*, 46–58. [CrossRef]
31. Voss, R.C.; Jansen, T.; Mané, B.; Shennan, C. Encouraging technology adoption using ICTs and farm trials in Senegal: Lessons for gender equity and scaled impact. *World Dev.* **2021**, *146*, 105620. [CrossRef]
32. Aydin, B. Public acceptance of drones: Knowledge, attitudes, and practice. *Technol. Soc.* **2019**, *59*, 101180. [CrossRef]
33. Lin, C.A.; Shah, K.; Mauntel, L.C.; Shah, S.A. Drone delivery of medications: Review of the landscape and legal considerations. *Bull. Am. Soc. Hosp. Pharm* **2018**, *75*, 153–158. [CrossRef]
34. Beck, S.; Bui, T.T.; Davies, A.; Courtney, P.; Brown, A.; Geudens, J.; Royall, P.G. An evaluation of the drone delivery of adrenaline auto-injectors for Anaphylaxis: Pharmacists' perceptions, acceptance, and concerns. *Drones* **2020**, *4*, 66. [CrossRef]
35. Johannessen, K.A. A Conceptual Approach to Time Savings and Cost Competitiveness Assessments for Drone Transport of Biologic Samples with Unmanned Aerial Systems (Drones). *Drones* **2022**, *6*, 62. [CrossRef]
36. Choe, J.Y.; Kim, J.J.; Hwang, J. Perceived risks from drone food delivery services before and after COVID-19. *Int. J. Contemp. Hosp. Manag.* **2021**, *33*, 1276–1296. [CrossRef]